SPECIFICATIONS

FOR

TRIPLE-EXPANSION TWIN-SCREW

PROPELLING ENGINES, WITH BOILERS AND AUXILIARY MACHINERY,

FOR

SEAGOING BATTLE SHIP No. 1,

OF

ABOUT 11,250 TONS CRUISING DISPLACEMENT,

TO MAKE A SPEED OF SIXTEEN KNOTS PER HOUR AT A DISPLACEMENT OF 11,250 TONS.

BUREAU OF STEAM ENGINEERING,

NAVY DEPARTMENT,

WASHINGTON, D. C.

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SPECIFICATIONS

FOR

TRIPLE-EXPANSION

TWIN-SCREW PROPELLING ENGINES,

WITH BOILERS AND AUXILIARY MACHINERY,

REFERENCE BEING HAD TO THE DRAWINGS ACCOMPANYING AND FORMING PART OF THESE SPECIFICATIONS.

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1. General Description.—The propelling engines will be rights and lefts, placed in water-tight compartments and separated by a middle-line bulkhead. These engines will be of the vertical inverted-cylinder, direct-acting, triple-expansion type, each with a high-pressure cylinder 39 inches, an intermediate-pressure cylinder 55 inches, and a low-pressure cylinder 85 inches in diameter—the stroke of all pistons being 48 inches. The collective indicated horse power of propelling, air-pump, and circulating-pump engines will be 11,000 when the main engines are making about 112.5 revolutions per minute. The high-pressure cylinder of each engine will be forward and the low-pressure cylinder aft. The main valves will be of the piston type, worked by Stephenson link motions with double-bar links. The valve gear of the three cylinders will be interchangeable. There will be one piston valve for each high-pressure cylinder, two for each intermediate-pressure cylinder, and four for each low-pressure cylinder. Each main piston will have one piston rod, with a crosshead working on a slipper

guide. The framing of the engines will consist of cast steel inverted Y frames at the back of each cylinder and cylindrical forged steel columns at the front. The engine bedplates will be of cast steel, supported on wrought steel keelson plates built in the vessel. The crank shafts will be made in three interchangeable and reversible sections. All crank, line, and propeller shafting will be hollow. The shafts, piston rods, connecting rods, and working parts generally, will be forged of mild open-hearth steel.

The condensers will be made of composition or sheet brass. Each main condenser will have a cooling surface of about 8,100 square feet, measured on the outside of the tubes, the water passing through the tubes. For each propelling engine there will be two independent horizontal double-acting air pumps, each worked by a single horizontal steam cylinder. The main circulating pumps will be of the centrifugal type, one for each condenser, worked independently. The propellers will be right and left, of manganese bronze or approved equivalent metal.

Each engine room will have an auxiliary condenser, made of composition ~~and sheet brass~~, of sufficient capacity for ~~one half~~ the auxiliary machinery, each condenser being connected with all the auxiliary machinery. Each of these connected with all the auxiliary machinery. Each of these condensers will have a combined air and circulating pump.

There will be three double-ended main and two single-ended auxiliary steel boilers of the horizontal-return fire-tube type, all constructed for a working pressure of 160 pounds per square inch. The boilers will be placed in four water-tight compartments as shown on the drawings. There will be two athwartship fire rooms in each of the main boiler compartments. Each of the double-ended boilers will have eight corrugated furnace flues, 42 inches internal diameter. The total heating surface of the main boilers will be about 23,951 square feet, measured on the outer surface of the tubes, and the grate surface 756. The after main boilers will be double ended, 16 feet 9 inches outside diameter and 19 feet long. The forward boilers will consist of one double-ended boiler 21 feet

long by 16 feet 9 inches diameter, and two single-ended boilers 9 feet 10½ inches long and 16 feet 9 inches diameter.

There will be placed in the forward fire rooms of the after boilers, and in the after fire room of the forward boilers, approved main and auxiliary feed pumps. There will also be an auxiliary feed pump in the fire room of the forward single-ended boiler. There will be, in addition to these pumps, approved auxiliary feed, bilge, water-service, fire, and other pumps, to be located and described hereinafter. There will be two smokepipes.

The forced draft system will consist of one blower for each fire room, the blowers discharging into an air-tight fire room. Air-tight bulkheads will be fitted so as to reduce the space to be maintained under pressure.

There will be steam reversing gear, ash hoists, coal-hoisting winches, turning engines, auxiliary pumps, engine-room ventilating fans, engine for workshop machinery, hydraulic pumping plant for various purposes, gun-table or turret-turning engines, ammunition-hoisting engines, a distilling and evaporating apparatus, and such other auxiliary or supplementary machinery, tools, instruments, or apparatus as are described in the following detailed specifications or shown in the accompanying drawings.

2. Cylinders.—They will consist of casings of best quality of cast iron, with working linings for the cylinders and valve chests. The cylinder casings will include the valve chests, steam ports and passages, the lower heads, and the various brackets to which the cylinder supports will be attached. The steam and exhaust ports will be smoothly cored to the dimensions shown in drawings, the walls of the passages being strongly stayed by ribs or bolts.

The brackets for securing the cylinder tie rods will be so faced that when bolted together the centers of the cylinders will be 9 feet 6 inches apart, with the cylinder axes all in one plane. The cylinder casings will be bolted at the bottom to their frames and columns by body bound steel bolts as shown, and secured to each other

at the top by forged steel stay rods, fitting in sockets on the cylinder casings. They will be in a vertical position when bored to their respective diameters.

3. High-pressure Cylinder Casings.—The lower head will be cast single with ribs as drawn, and the barrels will be 1⅜ inches thick. Each will have one double-ported piston valve. They will be faced and bored, as shown, for the reception of the working-cylinder linings and for the valve-chest linings. The brackets at the bottom for attachment of the supporting frames and columns will be well ribbed and faced. There will be brackets cast on the casing, as shown, faced and fitted for boxes, for securing the tie rods from the intermediate and low pressure cylinder casings. The walls of the steam passages will be properly stayed. There will be a 9 inch hand-hole in the lower head. There will be facings, flanged and ribbed where necessary, for the attachment of the cylinder and valve-chest covers, steam pipes, exhaust pipes, piston-rod stuffing boxes, relief valves, hand-hole plate, drain cocks, indicator pipes, drainpipes, and oil cups. The unfinished part of the bore will be pickled to remove the scale. There will be a lug cast on the after side of the casing as shown, fitting into a socket on the intermediate cylinder casing, to prevent side motion of the cylinder and allowing expansion in a fore and aft direction.

4. Intermediate-pressure Cylinder Casings.—The heads will be cast with double walls, the barrels will be 1½ inches thick. Each will have two piston valves. There will be brackets cast on the casing, faced and fitted for boxes, for securing the tie rods from the high and low pressure cylinder casings. There will be faced brackets for the supporting frames. There will be a 10 x 14 inch manhole in the lower head. There will also be facings for attaching the steam and exhaust pipes, receiver safety valves, receiver live-steam pipes, relief valves, jacket steam and drainpipes, piston-rod stuffing boxes, rock-shaft bearings, and manhole covers; also for indicator pipes, oil cups, and drain cocks. The unfinished part of the bore will be pickled to remove the scale.

5. Low-pressure Cylinder Casings.—The heads will be cast with double walls, the barrels will be 1½ inches thick. There will be brackets cast on the casing, faced and fitted for boxes, for securing the tie-rods from the intermediate-pressure cylinder casings. Each will have four piston valves. There will be faced brackets for the supporting frames, also facings for manhole covers, steam and exhaust pipes, auxiliary exhaust pipes, receiver safety valves, receiver live-steam pipes, jacket steam and drain pipes, relief valves, piston-rod stuffing boxes, rock-shaft bearings, indicator pipes, oil cups, and drain cocks. There will be a manhole 15 inches in diameter in the lower head. The unfinished part of the bore will be pickled to remove the scale.

6. Cylinder Linings.—They will be of close-grained cast iron as hard as can be properly worked, turned and faced to fit the cylinder casings. Each lining will have a bearing at about the middle of its length and at each end.

The linings at the top will be secured to the casings by round-headed countersunk steel bolts, placed radially around the counterbore, and spaced as shown on the drawings. The bolt holes in the linings will be counterbored to receive the heads of the bolts, the nuts being on the outside of the casings.

The linings, after being secured in place in the casings, will be smoothly and accurately bored to diameters of 39, 55, and 85 inches for the high, intermediate, and low pressure cylinders, respectively, and to a thickness of 1¼ inches, the boring to be done with the cylinders in a vertical position. The linings will be counterbored at both ends, leaving the working bores 4 feet 1¾ inches long. The unfinished parts of the linings will be pickled to remove scale.

The joint at the lower end of each liner of the intermediate-pressure and low-pressure cylinders will be made tight, with allowance for expansion, by a copper ring about $\frac{1}{16}$ inch thick. This copper ring will be backed by

a wrought-iron ring 1½ inches wide and $\frac{7}{16}$ inch thick, the two rings together being secured to the cylinder liner by ⅝-inch wrought-iron screws, spaced not over 3 inches.

A similar backing ring and screws will make a tight joint between the same copper ring and the facing provided on the cylinder casing. The facings of lining and casing and the edges of the backing rings will be chamfered to allow of free expansion.

7. Cylinder Covers.—They will be made of cast iron, well stiffened by ribs, each fitted with an 18-inch manhole. They will be so formed as to leave as little clearance as practicable.

Annular recesses will be cored for the heads of the piston follower bolts. Each cover will be turned and faced to fit its cylinder casing, bored and faced at manhole, and finished on outside and edges of flanges.

The cover of the high-pressure cylinder will be secured to the cylinder casing by thirty-eight, the cover of the intermediate-pressure by forty-two, and the cover of the low pressure by sixty-four 1⅜-inch steel studs.

Holes will be drilled and tapped for jack bolts and eyebolts.

The thickness of the covers will be 1¼ inches for the high and intermediate pressure cylinders and 1⅜ inches for the low-pressure cylinders.

8. Cylinder Manhole Covers.—They will be of cast iron, shaped as shown in the drawings, faced to fit manholes, and finished on the outside of flanges. They will be secured by 1⅛-inch steel studs, spaced as shown in the drawings, and will have holes drilled and tapped for jack bolts.

9. Cylinder Clearances.—Care will be taken that the clearances in the cylinders are made no larger than absolutely necessary. After the engines are set up in place and connected, the volume of the clearance at each end of each cylinder will be carefully measured by filling the space with water or oil, and the result plainly marked on some conspicuous part of the cylinder casing.

Marks will also be made on the crosshead guides showing the position of the pistons when the clearances were measured.

10. Steam Jackets.—The intermediate-pressure and low-pressure cylinders will be steam jacketed on sides and bottoms.

The space left around the working linings for steam jackets will be ¾ inch in depth. All ribs must be cored out so as to allow a free circulation of the jacket steam and a free drainage of the water of condensation.

Steam for the jackets will be taken from the main steam pipe in each engine room on the boiler side of each engine stop valve, by a 2-inch pipe. From this pipe a 1½-inch branch will lead to the intermediate-pressure jacket. This branch will have a 1½-inch adjustable spring-reducing valve, adapted to pressures of from 20 to 80 pounds above atmosphere.

Another 1½-inch branch will lead to the low-pressure jacket. This branch will have a 1½-inch adjustable-spring reducing valve, adapted to pressures of from 0 to 30 pounds above atmosphere.

Each branch steam pipe will have a stop valve close to the jacket.

There will be on each jacket steam pipe, on the jacket side of the reducing valve, a 1½-inch adjustable-spring safety valve, adapted to the same pressures as the reducing valves.

A 1-inch drain will lead from the lowest part of each jacket to an approved automatic trap with blow-through and by-pass pipes and valves, thence to the lower part of the feed tank, with a branch to the bilge. Each drainpipe will have a stop valve close to its jacket. The drainage system of the jacket of each cylinder will be entirely independent as far as the trap discharge, from which point the drains may be in common. All pipes in the jacket drain system will have union joints so as to be easily overhauled.

11. Valve Chests.—The valve chest of each high-pressure cylinder will be fitted for one piston valve, each intermediate pressure for two and each low pressure for four.

There will be openings at each end for inserting and removing the valves and working linings; the chests will be accurately bored and faced for the reception of the working linings.

Before the insertion of the linings, the steam and exhaust passages must be thoroughly cleaned out and pickled, and care taken that the passages are nowhere contracted to less than the specified areas.

Each intermediate-pressure and each low-pressure valve chest will have a 3-inch adjustable spring safety valve of approved pattern.. They will be loaded to 80 and 30 pounds, respectively, for the intermediate and low pressure chests.

All valve chests will also be fitted with approved composition drain cocks or valves that may be operated from the working platform, the valves to discharge through pipes into the bilge and feed tanks, with the necessary valves for directing the water to either.

12. Valve-chest Linings.—There will be a working lining at each end of each valve chest for each piston valve. They will be of close-grained cast iron as hard as can be properly worked, accurately turned and faced to fit the casings, and accurately bored to an internal diameter of 15½ inches in the high and 22¼ in the intermediate pressure, and 20 inches in the low pressure, leaving the walls 1¼ inches thick for the high, 1 inch for the intermediate, and 1 inch for the low pressure valve chests.

They will be forced into place, making all joints perfectly tight, and secured by screws tapped half into the linings and half into the casings.

The steam ports will have alternating right and left diagonal bridges, of such a section as to permit of the easy passage of steam, taking up not more than one fourth of the port area.

The edges of all ports will be finished to a uniform outline.

13. Valve-chest Covers.—They will be made of cast iron, as drawn, and will be well ribbed, as shown. They will

be finished all over on the outside, except the recesses between the ribs.

All flanges will be turned and faced to fit the openings in valve chests and finished on the outside and edges. Each lower cover will be faced and bored to receive the valve-stem stuffing boxes. The cylinder for the balance pistons for the valves will form part of the upper covers for the valve chests, and will be bored to diameters of 5½ and 8 and 7½ inches, respectively for the high pressure intermediate and low-pressure valves. Lugs will be fitted in the steam chests to prevent the rings from overriding the seats when valves are disconnected. There will be approved provision for proper oiling of the valve stems. Each upper cover of the valve chests will have a smaller cast-iron cover, finished all over, flanged and bolted on, over the openings for the balance pistons. The lower covers will have the necessary faces for securing valve-stem crosshead guides.

14. Piston Valves.—The high-pressure piston valve will be double ported of cast iron made without packing rings, with thickness as shown in drawings. The intermediate and low pressure valves will also be of cast iron but will be hollow pistons with follower, and packing ring. The two heads of each valve will be separated when in position by distance pieces of such lengths as to make the steam and exhaust laps as required.

The followers of the valves will be of cast iron or cast steel, secured in place by steel through bolts with wrought-iron nuts and brass split pins. The follower bolts will pass through lugs on the inside of the valve shell and have their heads so formed and fitted as to prevent turning, or they may be stud bolts squared where they pass through the follower, with square holes in the follower to correspond.

The packing rings will be of hard cast iron, turned larger than the bore of valve seat, cut obliquely, and bolted together as shown and fitted to liner.

15. Valve Stems.—The high-pressure valve stems will take hold of the link blocks.

The lower end of each intermediate-pressure and low-pressure valve stem will be secured to its crosshead by a collar nut above and below the crosshead, the nuts being kept from turning by set screws.

The holes in crossheads of valve stems will be elliptical.

The upper ends of the valve stems will be constructed as shown in drawings, for securing balancing pistons.

16. Valve-stem Crosshead Guides.—The valve-stem crossheads for the intermediate and low pressure valves will be made of forged or cast steel. They will be guided by a square rod working in a bearing to resist the angular thrust of the eccentric rods, and will be connected from each end to a rocker shaft, as shown, to prevent the valves altering their positions in relation to each other.

The rocker arms will be shrunk and keyed firmly to their shafts and the rocker shafts will vibrate in bearings bolted to facings on the cylinder castings. The high-pressure stem will be guided by a bracket bolted to the valve-chest cover.

17. Cylinder Relief Valves.—There will be an adjustable spring-relief valve of 4 inches diameter on each end of the high-pressure, intermediate-pressure, and upper end of low-pressure cylinders. The bottom of low-pressure cylinder will be provided with two 4 inch valves. The valves and their casings will be of composition. Pipes will lead from the relief-valve casings to the bilge with easily broken joints.

These valves will have nickel seats or their equivalent, and the valve fittings will be so constructed that the valves can be easily overhauled without slacking the springs and so that steam will not come into contact with the springs. The springs will have approved means of adjustment, and will be long enough to allow the valves to open to their full extent without unduly increasing the load. The valves will be guided by loosely fitting wings. The springs will bear on shoulders on spindles which fit loosely in sockets recessed in the backs of the

valves. These spindles will be so fitted that the valves can be moved by the application of a lever. The valves will be fitted with casings and drainpipes, which will prevent people being scalded by hot water from the cylinders. Suitable fulcrums will be on casings for the application of levers for working the valves, one lever to be furnished for each engine room. All springs must pass a satisfactory test.

The spring casing of each valve will be fitted with a suitable lock; all locks to have interchangeable keys.

18. Cylinder Drain Cocks.—Each high pressure and intermediate cylinder will be fitted with one and each low-pressure cylinder with two 1½-inch asbestos-packed drain cocks, placed so as to drain the cylinder thoroughly. The cocks must be perfectly tight without undue friction. The drain cocks of each cylinder of each engine will be worked by a separate lever at the working platform. All the drain cocks of each engine will discharge into a pipe leading to the fresh-water side of the condenser with a branch to the bilge. This pipe will have a stop valve near the condenser, and will have a spring non-return valve, without hand gear, which can open to the bilge discharge when the drain to condenser is closed, but which will prevent air entering the condenser at any time. Small drain cocks will be fitted to the lowest parts of drain pipes.

19. Engine Throttle Valves.—Each engine will have a 14½-inch throttle valve, bolted to the high-pressure cylinder casing.

Each throttle valve will consist of a balanced single poppet valve next the engine, working with a hand wheel or lever, and also a butterfly valve working with a lever. Both valves will be in one casing, the stem of the poppet valve being vertical and that of the butterfly valve horizontal. Both valves and their casing will be of composition. The butterfly valve will be so constructed as not to jam on its seat.

20. Piston-rod Stuffing Boxes.—They will be made of composition and fitted with approved metallic packing,

with efficient means of lubrication. The packing of each stuffing box will be made in at least two independent sections, so that in case of injury to one section the other will make a tight joint alone ; this packing to be in all respects equal to the best in the market, and subject to the approval of the Bureau of Steam Engineering.

21. Valve-stem Stuffing Boxes.—They will be made of composition and fitted with approved metallic packing, with efficient means of lubrication. The packing of each stuffing box will be made in at least two independent sections, so that in case of injury to one section the other alone will make a tight joint; this packing to be in all respects equal to the best in the market, and subject to the approval of the Bureau of Steam Engineering.

22. Pistons.—They will be made of cast steel, and will be conical. The followers will be made of cast or forged steel of such size and sections as shown in drawings, secured in place by 1¼-inch bolts, spaced as shown on drawings.

The follower bolts will be steel studs, screwed into the pistons; the bodies of the studs to be square, passing through square holes in the followers. The follower-bolt nuts will be of wrought iron, finished and case-hardened, each nut to be secured in place by a brass split pin of ample size.

Each piston will have two packing rings, each 1¼ inch wide and ¾ inch thick, of hard cast iron, cut obliquely and tongued.

The packing rings will be set out by steel springs of approved pattern, all set to an equal and proper tension. There will be sufficient clearance between the piston and cylinder to allow for difference of expansion.

Each packing spring must be so secured in the piston as to be firmly held in place and easily inserted and removed. The springs must be of best spring steel, properly tempered.

Each piston must be carefully gauged, and care taken that the clearance between the piston and cylinder head and cover is as called for on the drawings.

When completed the pistons must be carefully weighed, and no excess of weight will be allowed over that due to the dimensions shown in the drawings.

23. Piston Rods.—The piston rods will be of forged steel, 7½ inches diameter. They will be turned to fit the pistons with collars as shown, and fitted each with a composition nut at piston end, secured by a screw-stop pin. The parallel parts will be smoothly and accurately turned.

Each piston rod will have, at its seating in the piston, a collar of 9½ inches diameter and 1½ inch thick, well filleted, and recessed in the piston as shown.

The crosshead will be forged on the piston rod as shown, being formed to receive the brasses for the connecting rod pin.

24. Crossheads.—The body of the crossheads will be forged on the piston rod and will be shaped for the reception of the wrist pin brasses, caps, and the slipper guide.

The brasses will be 1¾ inches thick and will have a pin bearing of 10 inches diameter by 16 inches long. The caps will be of steel and will be held by two 4½-inch steel bolts.

The slipper will be bolted to the under side of the crosshead by four 2¼-inch bolts, with a cross key to take the shear. The slipper will be made of cast steel, shaped as shown, and will be lined with approved anti-friction metal both on the "go ahead" and "backing" sides. It will have a bearing surface of 27 x 20 inches on the ahead side.

25. Connecting Rods.—The connecting rods with their caps and bolts will be of forged steel, finished all over. They will be 96 inches long between centers, turned 7½ inches diameter at the small end and 8½ inches at the large end, the sides faced off to a uniform thickness of 7½ inches.

The crosshead end of each rod will be forked to span the crosshead, with the rod shrunk on to the pin and secured from turning by screw keys.

The diameter of the hole for the crosshead pin will be $\frac{1}{16}$ inch larger in one jaw than in the other.

The crank pin end of each rod will be increased in thickness to 15 inches, faced on each side and squared on the end for the brasses. A circular recess will be bored in the end of the connecting rod for the reception of a steadying boss on the back of the brass.

The crank pin end will be provided with brasses and steel cap.

The bolts will have recessed nuts and set screws.

The cap bolts will be provided with set screws for holding their weight when backing off the nuts, and in the upper end of the bolts there will be a tapped hole for screwing in an eyebolt for handling.

The bolts will pass through the brasses, the whole bolt being covered by the brass.

Composition distance pieces will be fitted between the brasses so as to be removable without taking out the bolts.

Each cap will have two eyebolts for handling.

26. Crank-pin Brasses.—They will be accurately fitted to the connecting rod ends and secured by the cap bolts as before specified. They will be fitted with approved white metal in strips, accurately fitted to the crank pins, and properly fitted for distribution of oil. They will be faced with sufficient clearance between crank webs to prevent nipping when heated.

27. Crosshead Brasses.—They will be accurately fitted to the crosshead pins, and properly fitted for the distribution of oil.

28. Engine Frames.—Each cylinder will be supported on one cast-steel inverted **Y** frame, and two cast or forged steel hollow cylindrical columns as shown in drawings. The upper ends of the frames and columns will be flanged and secured by steel body-bound bolts to the feet cast on the cylinders as shown, and the lower ends will be flanged, faced, and bolted to facings on the bedplates with body-bound bolts in the flanges as shown. The **Y** frames will be of the general thickness of ¾ inch with the flanges as shown on drawing. There will be facings provided for

reversing shaft brackets, as shown. The columns will have faced holes for tie rods, as shown.

The inside of the frames will have ribs and facings cast on them, to which will be bolted the cast-iron crosshead guides.

The space between the cast-iron guides and the column will be utilized for water circulation.

29. Bedplates.—They will consist each of steel castings of I section; the upper and lower flanges will be connected to the web and stiffened by ribs as shown. They will be properly finished and faced for crank-shaft brasses and caps, and for the flanges of the supporting frames and columns. The bedplates will be secured to the engine keelsons by 1¼-inch body-bound forged steel bolts, setting up on raised facings on the lower flange.

30. Crank-shaft Bearings.—The bearings for the crank shaft will be in two parts, the upper part and cap being a steel casting lined with white metal fitted into dovetailed recesses and hammered in place. The lower part of the bearing will be of composition, as shown, fitted as the cap, with white metal, and turned to fit a composition or steel chock in which it rests. The cap and bottom brass will have provision made for circulating water through them, and will be fitted with ample oil channels. Each cap will have an oval hand-hole for the purpose of feeling the journal. The hand-hole will have a box-shaped cover, for holding tallow, the bottom being perforated and extending to within a quarter of an inch of the journal.

The caps will be secured by four steel through bolts fitted as shown, each bolt 3 inches diameter, and having approved provision made against the nuts backing off.

The bolts will be screwed into square nuts, placed as shown, and will butt against a chock placed on the lower web to hold the bolt in position.

After the engines are secured in the vessel, the bearings will be bored out to perfect alignment if required. They will also be trued on their shafts and any defects made good by scraping to a proper bearing.

The bearing will be so fitted that the only bearing of the journal will be on the white-metal surface.

The bottom brasses will be so fitted that they can be removed without taking out the shafts.

There will be no flanges on the brasses or saddle, but the saddle will be held in place by tap bolts passing upward through the web of the frame as shown.

31. Crosshead Guides.—The guides to take the thrust of the crosshead will be of cast iron. They will be bolted to the facing cast on the inverted Y frames. The space back of the guides between the ribs and facings on the columns will form a water passage for circulation of water to keep the guides cool. Cast-iron lips will be bolted on each side of each go-ahead guide to take the thrust when backing. The guides will be smoothly and accurately finished, and will be fitted in place to proper alignment. Brass oil boxes will be screwed to lower end of each guide.

32. Valve Gear.—It will be of the Stephenson type with double-bar links. All valves will be worked direct. There will be one crosshead for the intermediate-pressure and two for the low-pressure valve stems.

The valve gear will be so adjusted that the mean cut-off in full gear for both ends of each cylinder will be about 0.7 stroke.

33. Eccentrics.—They will be of cast iron, each in two parts.

The two parts of each eccentric will be neatly fitted together and secured by two forged-steel bolts. They will be bored out to a snug fit on the seatings and turned accurately on the outside to an eccentricity of $4\frac{11}{16}$ inches for the high, the intermediate, and the low pressure. The seatings for the eccentrics will be on the crank shafts. The eccentrics will be recessed at each side for the flanges of the eccentric straps. Each backing eccentric will be securely keyed on the shaft, and each go-ahead eccentric will be secured to the corresponding backing eccentric by through bolts in slotted holes, the holes to be filled up after the eccentrics are set.

The eccentrics will have 5 inches face including rabbet.

34. Eccentric Straps.—They will be of composition, finished all over, made with flanges to fit the recesses of eccentrics and with lugs for the clamping bolts and for the eccentric rods. The two parts of each strap will be held together by two forged-steel bolts with finished heads, lock nuts, and split pins, and fitted with channeled brass distance pieces. Each strap will be lined with white metal fitted into dovetailed recesses and hammered in place. They will be accurately and smoothly bored to fit the eccentrics both on face and recesses, and properly channeled for oil.

35. Eccentric Rods.—They will be of forged steel, finished all over. Each rod will have a T head secured to its eccentric strap by two forged-steel stud bolts with nuts locked in place.

The upper end of each rod will be forked to span the link, and fitted with adjustable brasses, as shown.

The two brasses in the forks of each rod must be fitted accurately in line with each other, and smoothly bored to fit the link pins. The distance from centers of eccentrics to centers of link pins will be 8 feet 9 inches.

The high and low pressure eccentric rods will be open, and those of the intermediate pressure will be crossed.

36. Main Links.—They will be of the double-bar pattern, of forged steel, finished all over. They will all have the pins for eccentric rods forged on and finished to 25 inches between centers. Extensions of the pins at the ahead motion end of each link will form the pins for suspension rods. Each pair of bars will be secured together by through bolts of forged steel, and thimbles fitted with forged steel nuts well secured with split pins.

37. Link Blocks.—They will be of forged steel, finished all over. They will consist each of a link block terminating at each end in a pair of jaws to span the corresponding bar of the link. The jaws will be fitted with composition gibs finished to the curve of the links, the outer gibs being fitted with keys with screw adjustment

38. Suspension Links.—Each Stephenson link will be suspended from the corresponding arm of the reversing shaft by forged-steel suspension links.

The ends of these links will be fitted with brasses and caps on main links and reversing-shaft arms.

39. Valve-stem Crossheads.—The intermediate-pressure and low-pressure valve stems will have forged or cast steel crossheads, the crossheads taking hold of the link blocks directly. The ends of these valve stems passing through the bosses in crossheads will be threaded, and will be secured to crosshead by a collar nut above and below boss, the holes in the bosses being elliptical. The collar nuts will be kept from turning by set screws A key way will be cut in both the valve stem and its boss in the crosshead to receive a key to keep the valve stem from turning. The high-pressure valve stem will take hold of the link block directly. The high-pressure stem will be guided by a bracket bolted to the valve-chest cover.

The intermediate and low pressure valve-stem crossheads will have a square guide in the middle, passing through a guide bracket lined with composition, as shown. In addition to which they will be connected to rocker arms, as shown, to prevent the valves changing their position in relation to each other.

The bearings for these connections will be outside the valve stems.

40. Reversing Gear.—The reversing gear for each engine will consist of a steam cylinder and a hydraulic controlling cylinder, and acting directly on an arm fixed on the reversing shaft. The steam piston rod will be secured to a steel crosshead connecting with the arm on the reversing shaft. The piston rod will pass through the controlling cylinder with uniform diameter. The valve of the steam cylinder will be of the piston pattern, of composition, working in a composition-lined valve chest. There will be a by-pass valve on the hydraulic cylinder, which will be worked by a continuation of the stem of the steam piston valve. These valves

will be worked by a system of differential levers, the primary motion being derived from the hand lever on the working platform and the secondary motion from a pin on the reversing arm, all parts being so adjusted that the reversing engine shall follow the motion of the hand lever and be firmly held when stopped. There will be a stopcock in the by-pass pipe of the hydraulic cylinder, and a pump for reversing by hand will be connected to the hydraulic cylinder with its lever convenient to the working platform. The by-pass pipes will be connected to the valve box of the handpump in such a way as to leave the hand arrangements always in gear. The piston of the hydraulic cylinder will be packed by two cup leathers. Steam for the reversing engine will be taken from the auxiliary and main steam pipes outside the throttle valve.

41. Reversing Shafts.—There will be one forged steel reversing shaft for each engine. It will have six arms, two for the reversing engine and one for each link. The shaft will be supported by suitable bearings. Each reversing arm for the links will be made with a slot fitted with a cast-steel block, to which the suspension rods will be attached. Each block will be adjustable in the slot of its arm by a screw and hand wheel with approved locking device, and will be fitted with a suitable index. The slots in these arms will be so arranged that the links may always be thrown into full backward gear irrespective of the position of the block in the slot; and the length of the slots will be such that the cut off may be varied from about 0.5 to 0.7 of the stroke. All the arms will be neatly fitted and keyed to the shafts.

42. Exhaust Pipes.—Leading from the exhaust side of the high pressure valve chest there will be two copper exhaust pipes, one on each side, leading to the valve chest of the intermediate cylinder. These pipes will increase from 12½ inches diameter at the high pressure chest to 14 inches at the intermediate pressure chest. From the exhaust side of the intermediate chest four copper pipes will extend, two on each side, to the low

pressure steam chests. These pipes will leave the I. P. cylinder with a diameter of 15 inches. They will be met by 13½-inch branches from the forward steam chest and will continue with a diameter of 13½ inches to the after steam chest. There will be slip joints in these pipes both forward and aft of the forward L. P. steam chest. There will be composition pipes 26¼ x 14½ inches, running into a round section 21 inches diameter from the L. P. exhaust nozzles. These will be connected to the condenser by a 21-inch copper pipe.

43. Reversing-shaft Bearings.—They will be made of cast iron with bottom brasses and composition caps, and will be securely bolted to their supports. They will be bored to fit the journals of the shafts.

The caps will be secured with bolts and lock nuts.

44.—Working Platforms.—The floors on the inboard side of each main engine, between the high and intermediate pressure cylinders, will be conveniently arranged to serve as working platforms. The counter, revolution indicators, clocks, gauges, telegraph dials, and other engine room fittings will be so placed near the working platforms as to be in full view while working the engines. Speaking-tube mouthpieces and telegraph levers will be conveniently placed.

45. Working Levers and Gear.—There will be at each working platform the following hand gear, viz :

One reversing lever ;

One hand wheel for letting live steam into intermediate valve chest ;

One hand wheel for letting live steam into low-pressure valve chest ;

Three cylinder drain-cock levers; hand-reversing pump lever ; throttle-valve lever ; bleeder-valve hand wheel ; reversing-engine stop-valve hand wheels for steam and exhaust ; throttle stop-valve hand wheel.

Reversing and drain cock levers will have spring latches of "locomotive pattern." The latches on reversing levers will be of the best type and subject to the approval of the Bureau of Steam Engineering.

46. Shafts.—All the crank, line, thrust, and propeller shafts will be of forged steel. Each length will be forged solid in one piece, and will have a hole drilled axially through it and through the crank pins from end to end. All shafts will be finished all over. They will be supported as shown.

47. Crank Shafts.—There will be three sections of crank shafts for each propelling engine, reversible and interchangeable. Each section will have a crank of 24 inches throw, and will have a coupling disk forged on each end. The coupling disks will be 3½ inches thick and 30 inches diameter. The length of each section of shaft will be 9 feet 6 inches. There will be two journals on each section of shafting, one on each side of the crank, 16 inches in diameter and 18 inches long.

The crank pins will be 16 inches diameter and 19 inches long.

The crank webs will each be 17 inches wide and 10 inches thick. The webs to be chamfered as shown in the drawings.

There will be a raised seating on each section of shafting for the eccentrics. The crank pins must be accurately parallel to the main journals. All journals are to be smoothly and accurately turned, and when finished will be tested and their accuracy proved. There will be a hole 7½ inches in diameter bored axially through each shaft and crank pin of engines. When bolted together the cranks of each engine will be at angles of 120° to each other—the intermediate to follow the high pressure and the low pressure to follow the intermediate.

The ends of the hole in each crank pin will be closed by a brass plate fastened on with countersunk screws.

Two radial ½-inch holes will be drilled in each crank pin from the outside of the bore.

The various lengths of the crank shafts will be coupled to each other by six 3¾-inch forged steel bolts in each pair of couplings. All holes in each coupling will be drilled or reamed to template. The bolts will be finished to fit the hole snugly, and each fitted with wrought-iron nut and split pin.

Paragraph 49 will be so amended as to read:

There will be one section of *Nickel Steel* line shafting for each engine supported on two bearings, as shown. Each section will be $15\frac{3}{4}$ inches in diameter with a $9\frac{3}{4}$-inch axial hole. The couplings will be the same as those in crankshaft. The length of shaft will be taken from work.

A worm wheel for turning the shaft will be fitted where directed.

48. Thrust Shafts.—They will be 15¾ inches in diameter, about 12 feet long over all, with 7½-inch axial holes. Each shaft will have 12 thrust collars 2 inches wide, with spaces of 3 inches, the collars to be 21 inches outside diameter. There will be coupling disks forged on the forward and after ends 3½ inches thick and 30 inches diameter. There will be a raised seating on the thrust shaft of the same diameter as those on the crank shaft for the after low pressure eccentrics.

The bolt holes in the couplings will be drilled or reamed to template, and will be spaced the same as those in the crank-shaft couplings.

49. Line Shafting.—There will be one section of line shafting for each engine, supported on two spring bearings, *as shown*. Each section will be 15¾ inches in diameter with a 7½-inch axial hole. The couplings and bolts will be the same as those in crank shaft. The length of shaft will be taken from work.

50. Propeller Shafts.—The propeller shafts will each be in one section, 17½ inches diameter and about 46 feet 6 inches long over all. The length of this shaft will be taken from the ship. A 12-inch axial hole will be bored through the shaft, the hole being tapered where it passes through the propeller hub. At the forward end the hole will be reduced to four inches. It will be covered from the forward coupling to 2 inches abaft the forward fair water casing and from 2 inches forward the fair water casing on the strut to one inch inside the propeller hub, with a composition casing shrunk and pinned on and perfectly water tight. The joints will lap over each other one inch. The ends of the casing will be tapered except inside of the propeller hub, and protected by a filet of soft solder. The casing will be ¾ inch thick in the bearings and at the joints and ½ inch thick elsewhere. The after end of the casing will make a water tight joint with the propeller hub. The inboard end of the shaft will be fitted with a forged steel coupling 13 inches long secured by three steel keys. Back of this coupling there

will be a groove 5 inches wide and 1 inch deep, cut in the shaft, in which will be fitted a collar in halves of the same diameter as the outside of the coupling, and secured to it and to the coupling on the line shaft by six 3¾-inch fitted steel bolts. The shaft outside the casing will be well coated with the same composition as the hull.

There will be a steel fair water casing from the after end of the sterntube and forward of the propeller strut as shown in drawings.

51. Lubrication.—All working parts of the machinery will be fitted with efficient lubricators, each with a sufficient oil capacity for four hours' running. Each lubricator to be fitted with a tube leading to the wipers on the moving parts, or tubes in the bearings and guides. Each tube from the lubricators will be fitted with a valve adjustment and a sight feed with a well protected glass tube.

There will be in each engine room for each engine a 5-gallon oil tank, well tinned on the inside, and fitted with a glass gauge, filling pipe, and air cock. Each tank will be connected to all the lubricators on its engine by ½-inch brass or copper pipes, as may be directed, the tank to be placed in such a position that oil will flow to each lubricator.

Unions will be fitted where necessary, so that the oil pipes may be quickly taken down and cleaned, and each pipe will be connected to the bearings by a union joint. Each main crank pin will be oiled by cups carried on the connecting rod—taking oil from wicks overhead; the oil to be carried to the crank pins by brass pipes secured to the connecting rods. These pipes will have union joints where connected to oil cups.

Each main crosshead journal will take oil from an overhead wick cup.

Each crosshead guide will be oiled by pipes connecting with holes leading to about the middle of each guide.

Pipes, fitted as above specified, will lead from the lubricators to the following parts of each engine: Piston rods, valve stems, valve links, reversing-shaft, and guide rocker shaft bearings.

Each balance piston and each piston valve will have a globe oil cup, placed sufficiently high to insure the oil running where desired without regard to the trim of the vessel.

The upper end of each eccentric rod will carry an oil cup on each fork; these cups to take oil from pipes leading from an oil cup attached to the suspension rod of the link near the rock-shaft arm pin. The link-block pins will be lubricated by wiper oil cups, fed from fixed cups overhead.

Each eccentric will have a long oil cup fed by a drip pipe, so arranged that the eccentric will be lubricated in all positions.

There will be a small oil tank, with glass gauge, placed in a convenient position, and connected by pipes with a closed oil box at each crank-shaft bearing, so that when necessary oil can be supplied to the journals under a head. From each of these boxes three tubes will lead to the bearing, each with valve adjustment, and with a sight feed with a well protected glass tube.

If flexible couplings are used they will be fitted with a centrifugal oiling apparatus, with a pipe leading to each bolt head in the coupling disk placed upon each suspending rod.

There will be fitted to each main steam pipe, close to each high-pressure valve chest, an approved steam sight-feed oil cup of two quarts capacity, with gauge glass. As far as possible all the oil for the moving parts of each engine, except main bearings, will be supplied from one oil box on the cylinder with separate valve, sight feed, and pipe for each part to be oiled. There will be a steam sight-feed cup on each circulating, blowing feed, air-pump, and bilge-pump engine. Each blower engine will have a continuous automatic lubricator of approved pattern. All working parts for which oil cups are not specified or shown in drawings will have oiling gear of approved design, such that they can be oiled without slowing. All the oiling of each auxiliary engine will be done by one oil box where practicable. All fixed oil cups will have hinged covers, with stops to prevent being opened too

far. Moving oil cups, where necessary, will have removable covers. The supply of oil to various parts is to be easily regulated. All oil cups and their fittings, except such as are cast on bearings, will be of finished cast brass or of sheet brass or copper, as may be directed, with all seams brazed.

52. Oil Drips.—All fixed bearings will have drip cups cast on where possible, otherwise they will be of cast brass, properly applied. All moving parts will have drip cups or pans cast on engine frames where directed, otherwise to be substantially made of sheet brass or copper, with brazed seams. All drip cups will have drainpipes and cocks of at least ½ inch diameter, which can be used while the engines are in operation.

53. Journal Boxes.—All journals or moving parts of iron or steel will run, unless otherwise specified, in composition boxes. These boxes will be lined with approved anti-friction metal where directed. All adjustable bearings will be provided with channel brass chipping pieces, securely held in place and easily removable.

54. Mandrels for White-metal Bearings.—Hollow cast-iron mandrels will be furnished for forming the white-metal linings of crank pin, crank shaft, line shaft, and thrust bearings. All these will be smoothly and accurately turned to size, and packed so as to be perfectly protected.

55. Stuffing Boxes.—All iron boxes will be bushed with composition. All glands will be of composition and fitted with approved means of adjustment while the engines are in operation, and those not fitted with pinion nuts and spur rings will have lock nuts and split pins. Metallic packing of approved kind, and subject to the approval of the Bureau of Steam Engineering, will be fitted in stuffing boxes of all piston rods and valve stems of main and auxiliary engines. For piston rods and valve stems over 1¾ inches in diameter the packing will be in at least two independent sections; for piston rods and valve stems between ¾ and 1¾ inches diameter, it will be made in one section.

56. Bolts and Nuts.—All bolt heads and nuts less than 3 inches, except in special cases, will conform to the United States Navy standard. Screw threads on bolts and nuts must in all cases conform to the above standard. All finished bolts, except as directed, will be kept from turning by dowels or other suitable devices.

The nuts of all bolts on moving parts and on pillow blocks, and elsewhere as shown, will be locked, and the bolts will extend beyond the nuts, without threads, and will be fitted with split pins.

57. Thrust Bearings.—Each thrust-bearing pedestal of cast iron will be bored out to receive the lower part of bearing, and firmly bolted to the seating provided. The bearing will be in two parts, of cast iron, with white-metal linings. The lower part will be finished to fit the pedestal. The upper part or cap will be separated from the bottom by composition distance pieces, and will be fitted in place with wrought-iron dowel pins, fitting snugly in holes in the lower part of bearing. The cap will be faced to fit longitudinal recesses in the upper flanges of pedestal, and will be held down by bolts, body bound in pedestal, but with slotted holes in cap. Each cap will have a box cast on top with a hinged cover.

The end and side walls of the pedestal will form an oil trough, from which there will lead an oil hole to each collar and each recess, the white metal being properly channeled for distribution of oil. Inside this trough, both forward and abaft the thrust collars, will be a composition bearing for taking the weight of the shaft. The cap for this bearing will be of cast iron lined with white metal. These bearings will be adjustable vertically by wedges with regulating screws

At each end of each thrust bearing there will be a divided stuffing box and gland to prevent escape of oil. At the bottom of each thrust bearing there will be a fore and aft channel connecting all the bearing recesses, the connecting holes to each of at least 1 square inch in area; a drain cock will be fitted at each end.

The oil trough will also be fitted with a cooling coil. There will be four adjusting screws, two at each end of

the thrust-bearing pedestal for adjusting the bearing fore and aft. The caps will be fitted with eyebolts for convenience of handling.

58. Jacks for Coupling Bolts.—A hydraulic jack of approved pattern will be fitted for withdrawing the bolts of the shaft couplings.

59. Stern-tube Bearings.—Each stern tube will be finished as follows: It will be made of mild steel with internal cast-steel rings at each lignum-vitæ bearing. Fitted to these rings there will be a composition bushing, the inner one made in halves, the joints to be in a horizontal plane when bushing is in place. These bushings will be fitted with sections of lignum-vitæ, put in so as to wear on end of grain, and smoothly and accurately bored in place to suit the shaft casing. All the lignum-vitæ bearings will be well water-soaked, and bored out in place to perfect alignment and to a loose fit on the shaft casing.

60. Stern-tube Stuffing Boxes.—At the forward end of each stern tube there will be a composition stuffing box, made in halves, divided longitudinally. It will be bolted to the flange on the forward end of the stern-tube bushing. The two parts will be bolted together along the longitudinal division by proper flanges. The follower will be of composition, in two parts, with a space of 1¼ inches between the parts on each side. The packing spaces will be about 7 inches deep and 1 inch wide.

The follower bolts will be of rolled manganese or Tobin bronze. To each stuffing box, abaft the packing, a 1½-inch pipe will be attached, leading to the engine-room bilge. It will also be connected with the engine-room water-service pipes, and will be provided with valve, so that the bearing can be drained into the bilge or washed out by water from the engine-room pump at will.

61. Stern-tube Bracket Bearings.—Each stern-bracket bearing will have a neatly fitting composition lining, made in halves, divided longitudinally. It will have a

flange by which it will be secured to the forward end of the stern bracket. It will have a lignum-vitæ bearing, fitted as in the stern tube. The lignum-vitæ will be held in place at the after end by a flat ring bolted to the lining. A cast-steel sleeve will be secured to each stern bracket by screws, to form a fair-water line to the propeller boss. At the forward end of each bearing there will be a composition sleeve, secured to and supported by an extension of the lining before mentioned. This sleeve will be shaped to form a fair-water line from the shaft to the stern-bracket boss, and will be finished on the outside.

62. Screw Propellers.—They will be of manganese bronze or approved equivalent metal. The starboard propeller will be right and the port one left handed. Each blade will be firmly bolted to the boss by tap bolts of rolled manganese or Tobin bronze, secured by lock plates. The recesses for the bolt heads will be covered by composition plates held by countersunk screws, and finished to form a smooth surface fair with the boss. The bolt holes in the flanges of the propeller blades will be made oval to allow of adjustment of the pitch.

Each boss will be accurately bored to fit the taper on after end of shaft and fitted with a feather key. Each propeller will be held on the shaft by a nut screwed on and locked in place. The shaft casing will enter about 1 inch into the propeller boss and be fitted water-tight. Each boss will be finished at the after end by a composition cap bolted on water-tight; the bosses and caps will be finished all over. The blades will be cast as smoothly as possible and have any roughness removed. The flanges of the blades will be turned and faced to fit the recesses in the bosses accurately, and, after being secured in place, must have the edges made fair.

63. Condensers.—There will be one main condenser in each engine room. They will be cylindrical, 6 feet internal diameter, made in three sections, of composition $\frac{7}{16}$ inch thick.

There will be the following openings in each main condenser, with properly faced flanges, viz:

Two for main exhaust pipes, each 21 inches diameter;

One for auxiliary exhaust pipe, 7½ inches diameter;

One for bleeder valve, 6 inches diameter;

One for air pump, 4 inches diameter;

One for circulating pump, 4 inches diameter;

Two for air-pump suction pipes, 13½ inches diameter;

One for salt-feed pipe, 2 inches diameter, with a spray in the exhaust passage;

One 1½-inch nozzle, in each hand-hole plate at bottom of condenser, for steam pipe for boiling the water in condenser;

One hand-hole in the top of each tube sheet, as shown, 7 inches by 12 inches;

Two hand-holes at the bottom, 8 inches diameter, and one at each end in the tube sheets 4 x 6 inches.

The condensers will have brackets cast on the bottom, as shown, which will be faced and bolted to the seats on the air pumps.

The flanges next the tube sheets will be widened at the side next the bulkhead for fastening the ties which connect the condensers to the bulkheads. The condensers will be rights and lefts.

The condenser tube sheets will be made of composition 1 inch thick, with smoothly finished holes for the tubes, tapped and fitted with screw glands for packing the tubes. The glands will be beaded at outer ends to prevent tubes from crawling and will be slotted to admit a tool for screwing up. Cotton-tape packing will be used. There will be 4,126 seamless-drawn brass tubes in each condenser, ⅝ inch outside diameter, No. 18, B. W. G., in thickness. The tubes will be 12 feet long between tube sheets, and will be spaced $\frac{15}{16}$ inch between centers. The cooling surface of each condenser will be about 8,100 square feet, measured on the outside of the tubes.

The sections of each condenser will be bolted together, as shown. The tube sheets will be secured to the flanges of the shell by rolled manganese or Tobin bronze collar bolts, which will also be used for fastening the circulating-water chests.

The chest for the entrance and exit of circulating water will consist of a ring 9½ inches deep and ½ inch thick, provided with nozzles as shown, for the entry and delivery pipes, each 16 inches diameter, and with flanges for bolting to the condenser and to the bonnet. The bonnet will be ½ inch thick, and will be provided with four 14-inch manhole plates and well stiffened with ribs, as shown. It will also be secured to the tube sheet by four ¾-inch bolts as shown. These bolts pass through a cross rib which forms a diaphragm for directing the water through the lower half of the tubes, returning to the exit through the upper half. The bonnet will be provided with lugs for handling. The water chest at the other end of the condenser will be similar, with the exception of the nozzles and diaphragm. Both chests will have an air cock at the top and drains at the bottom.

There will be four braces of rolled manganese or Tobin bronze connecting the tube sheets, each ¾ inch in diameter, and each passing through a stay tube about 1½ inches external diameter and ¼ inch in thickness.

Baffle plates of brass will be fitted, as shown, to direct the steam over all the tubes. Plates will be provided for supporting the tubes.

In front of the main exhaust nozzles, above the tubes, will be deflecting plates, supported as shown.

A copper tank, pipe, and cock will be provided for admitting an alkaline solution into the condensers—this pipe to connect with the salt-feed spray; the tank to be of at least 10 gallons capacity and conveniently placed. Two 1½-inch branches connected with the auxiliary steam pipe will lead to the bottom of the condenser for cleaning the tubes by boiling.

Drain cocks will be provided with pipes leading to the bilge.

Each main condenser will be connected with the evaporators by a pipe and valve of approved size.

There will be a 3-inch spring safety valve on one of the exhaust pipes near the condenser, loaded to 25 pounds above atmosphere.

All parts of the condensers, except as otherwise specified, will be made of the same composition as the tubes.

All bolts will be made of rolled manganese or Tobin bronze. All bolts for securing flanges of pipes and manhole plates will be standing bolts, and will, wherever possible, be screwed into the condenser plates, with heads inside. The condensers must be perfectly tight all over, and be so proved after being secured in place.

64. Auxiliary Condenser.—Each engine room will have an auxiliary condenser of sufficient capacity for three-fourths the auxiliary machinery, each condenser being connected with all the auxiliary machinery. Each auxiliary condenser will be connected with the evaporators by a pipe and valve of approved size. The shell of the condenser will be made of composition, the heads and tube plates of composition. The diameter and spacing of the tubes and the packing will be the same as used in the main condenser. It will have faced flanges for inlet and outlet of the condensing water, hand-hole plates, soda cocks, drain cocks, auxiliary exhaust pipe, and pipe from evaporator.

65. Auxiliary Air and Circulating Pumps.—There will be a combined air and circulating pump of approved size and type for each auxiliary condenser. The pump cylinders, pistons, and rods will be of composition or bronze; all other working parts will be of wrought iron or steel.

66. Air Pumps.—There will be two horizontal double-acting air pumps, each driven by a single steam cylinder, for each propelling engine. Each steam and water piston will be attached to the same piston rod. The steam and water cylinders will be secured to each other by suitable cast-iron framing. Feet will be cast on each steam and water cylinder for securing it to its foundation. Each air pump will have a piston working in a cylinder 19 inches in diameter. The stroke will be 24 inches. The piston will be of composition, cast hollow. The wearing surface will be 8 inches wide and contain grooves for water packing. The pistons will be flat. The pump piston rod will be made of rolled phosphor bronze or approved equivalent metal. The steam piston rod will be of forged steel. The pump cylinder will be lined

with a composition lining ½ inch thick, secured as shown. The inner head will be cast with the pump cylinder, and will be ribbed, and as shown, for securing the stuffing box and the framing to connect with steam cylinder. The outer head will be removable: Both heads will slope inward from the top to the bottom of the cylinder, thus allowing a free flow of the water to and from the pump cylinder.

The pump casing will be of composition of a general thickness of ½ inch and well stiffened by ribs. The cylindrical portion of the casing inclosing the pump liner will be ⅝ inch thick; this thickness is reduced to ½ inch at the ends and renders practicable the withdrawal of the liner. The pump casing will be continued up above the working cylinder a sufficient height to allow the formation of a water column of such volume that the water level will, in following up the piston, never fall below the top of the pump cylinder. The suction-valve seats will be cast in the pump casing.

They will be so arranged as to be covered with water and will be spaced along three sides of the casing above a channel way of the form shown, the suction pipes entering into this at the pump ends. All ribs in the pump casing will be so arranged as to prevent the formation of air pockets between the foot and delivery valves. The delivery-valve seats, two for each pump, will be castings, separate from the pump casing. They will be well ribbed and will rest upon faced flanges at the top of the pump casing. The delivery-valve chamber will be supported upon the same flange as the valve seats, as shown, one set of stud bolts securing both. The delivery-valve seats will, however, in addition, be bolted down to the flange carried by the diaphragm separating the pump ends. The delivery-valve chamber will be strongly ribbed and carry faced supports for supporting the condenser.

There will be six foot and nine delivery valves for each end of the pump of 6 inches diameter of opening. The valves will be composed of three flat disks of rolled manganese bronze or approved equivalent metal $\frac{1}{32}$ inch thick,

and will be held in place by a guard and spiral spring of phosphor bronze or approved equivalent metal. The valve studs will be of similar material. The valves and guards must be easily removable and held firmly in place. The valve gratings must be so arranged as to give a clear opening of 21 square inches through each valve.

Suction pipes 13½ inches in diameter, with 9½-inch branches to each pump, will connect the ends of the condenser to the corresponding end of the pump. Straightway valves will be placed in the suction and discharge pipes so either pump can be overhauled without stopping the other pump from working on the condenser. The delivery pipes will be of copper, 9½ inches in diameter, and will lead to the feed tank.

Bonnets will be suitably arranged so that the valves can be easily examined or overhauled. The bonnets and cylinder heads will be fitted with jack bolts and eyebolts.

Each steam cylinder will take steam from the auxiliary steam pipe, and also from a branch of the main steam pipe, with a stop valve having a hand wheel at the working platform, and will exhaust by a special pipe into the condenser, and there will also be pipes and valves through which it can exhaust into the intermediate and low pressure receivers.

Each air pump, together with its condenser, must maintain a vacuum of within four inches of mercury of the atmospheric barometer with the propelling engines at full power under forced draft.

67. Circulating Pumps.—There will be one centrifugal, double-inlet circulating pump for each condenser, driven by independent engines of approved pattern, and of sufficient power to secure the results specified. The engine valves will be of either the slide or piston type. Each pump must be capable of discharging 11,000 gallons of water per minute from the bilge. The pumps will be made of composition, except as otherwise specified. Each pump casing will be made in two parts, divided in a horizontal plane, the upper part with conveniences for hand-

ling. The suction nozzle will have an opening for sea suction not less than 16 inches diameter, and a 16-inch opening for bilge suction. The pump runners will be smoothly cored, finished on the outside, and perfectly balanced. The shafts will be of phosphor bronze or other approved metal. The bearings will consist of sections of lignum-vitae, on end of grain, dovetailed into composition split sleeves, which will be well secured against turning. The stuffing-box glands will be each in two parts. There will be an air cock at the top of the pump casing and a drain cock at the bottom. The pump casings must be made as light as possible consistent with strength, and must be smoothly cored, with easy bends wherever the direction of the flow of water is changed. The circulating pumps will take steam from both main and auxiliary steam pipes.

68. Circulating-pump Connections.—Each circulating pump will be fitted with pipes and valves to draw from the sea or engine-room bilge, and will deliver into the condenser or direct to the outboard-delivery pipe by a pipe connecting inlet and outlet of condenser. This pipe and the inlet and outlet pipes of condenser each to have a straight-way valve.

The injection and delivery pipes for condenser circulation will be not less than 16 inches internal diameter.

There will be stop valves in the pipes leading from the sea and from the bilge to the circulating pump in each engine compartment. These valves will be so connected by a locking device that when one is open the other is shut; and both will be worked by hand wheels well above the floor plates.

69. Sea-injection Valves.—There will be one screw main injection valves of not less than 16 inches diameter in each engine compartment, one for each condenser. Each will connect with the sea by a conical steel tube through the double bottom.

There will be a strainer on each pipe at the ship's side. The hand wheels of these valves must be easily accessible above the engine-room floor plates.

There will be a 1½-inch steam pipe leading from the auxiliary steam pipe to the injection pipe outside of injection valve. This pipe to have a valve at each end.

70. Bilge-injection Valves.—They will be as specified under the head of "Bilge-suction Pipes."

71. Outboard-delivery Valves.—There will be in each engine compartment one straightway main outboard-delivery valve 16 inches diameter.

The valves in each compartment will connect with a steel pipe about ⅝ inch thick, passing through the longitudinal bulkheads as shown. The hand wheels will be accessible from the engine room.

72. Feed Tanks and Filter.—There will be a feed tank for each engine room, placed as shown in the drawing. Each tank will have a capacity of about 2,000 gallons. It will be made of ¼-inch wrought iron. It will be braced internally as may be directed. Each tank will have at least 250 cubic inches of rolled zinc plates, about ½ inch thick, suspended from the braces. The straps suspending the zinc plates and the braces where the straps come in contact will be filed bright before being secured in position. The parts to be then well painted on the outside, or the joints to be made water-tight in other approved manner. A portion of the tank will be fitted as a filter so that the entering water will rise through the filtering material into which the water from the air pumps will be delivered. The filter will be provided with sponges, or other approved material, and so arranged that it will be readily accessible. Each tank will have a manhole with bolted cover, and will have a glass water gauge with suitable guards, shut-off cocks, and drain cocks, and will be fitted and lagged with black-walnut lagging.

Each tank and filter will have the following pipe connections: A discharge pipe from each air pump in the same engine room; an overflow pipe leading to bilge, but so arranged that any water passing down it may be seen; a suction pipe to feed pumps, with valve; drain pipes from traps, as elsewhere specified; a vapor pipe, 3 inches

diameter, of copper, No. 16, B. W. G. The vapor pipe will lead up the engine-room hatch and discharge above the level of the awnings, where it will have a suitable hood, or it may be led into the main escape pipe. Each feed-pump suction will be provided with a balanced valve operated by a copper float in the feed tank, so arranged that it will allow no air to enter the feed pipes. All trap discharges and drains will enter the feed tanks well below the ordinary water level.

73. Grease Extractors.—If ordered, grease extractors, to be approved by the Bureau of Steam Engineering, will be fitted where directed.

74. Feed-tank Suction Pipes.—A pipe will connect the feed tanks in both of the engine rooms. From each tank there will be a suction pipe for the main feed pumps in the fire room, and a suction pipe for the auxiliary feed pumps in the same engine room.

Non-return valves will be fitted in the feed-pump suctions close to the pumps and straightway valves at the tanks. The suction pipes for the main feed pumps will be connected by pipes and valves so that the pumps can take water from either tank. The suction pipes for the auxiliary pumps will be connected in the same manner.

75. Suction Pipes from Bottoms of Condensers.—From each air-pump channel way below the foot valves a 2-inch pipe will lead to the feed-pump suction pipes, with a screw-down non-return valve.

76. Sea-suction Pipes.—A pipe will lead from a sea-suction valve in each engine room to the fire and bilge pump, the auxiliary condenser pump, and the water-service pump, and the auxiliary feed pump in its compartment. A pipe will lead from a special sea valve, fitted where directed, to the distiller circulating pump. Each of these pipes will be of at least the same bore as the nozzle on the pump with which it connects. Each sea suction will be controlled by a valve which will not permit sea water to enter any of the bilge-suction pipes or feed-tank suction pipes. Each sea-suction valve will have a steam pipe connection below the valve for cleaning strainer.

77. Bilge-suction Pipes.—There will be the following suction pipes from the bilge and from the drainage pipes to the various pumps:

A 16-inch copper pipe will connect to each circulating pump, with a stop valve close to the pump, as before specified. This pipe will have two branches of such size as may be designated; of these one will connect with the main drainage system, with a screw-down non-return valve which can be lifted from its seat by means of its stem; the other branch will connect directly with the bilge in its own compartment, and be fitted with a non-return valve which can be lifted from its seat by means of a sliding stem, but without means of fastening it shut except by lashing the lever by which its stem is worked. This branch will be fitted with a Macomb or equivalent bilge strainer of approved size.

There will be provided in each engine room a manifold or suction box, with the following connections, viz:

A 3-inch pipe leading from the lowest part of compartment abaft the engine room;

A pipe of the size of the combined areas of the suction nozzles of the two 350-gallon pumps, from the secondary drainpipe;

A pipe of the same size from the main drainage cistern;

A pipe to each, 350-gallon pump, in its own engine room of the same size as the pump suction nozzle;

All these pipes will be provided with screw-down non-return valves.

Macomb or equivalent bilge strainers will be inserted in the suction pipes between the box and pumps.

There will be no other strainer or valves in any of these pipes other than those herein specified.

There will also be manifolds connecting with the 350-gallon pumps and with the double-bottom compartments, in accordance with the hull specifications.

Each auxiliary feed pump in the fire rooms will have a suction pipe of the full size of its suction nozzle connected with the secondary drainpipe. In addition to these the forward auxiliary feed pumps will have a 3-inch suction from the lowest part of the bilge of the

first compartment forward of the double bottom. The suctions to each pump will lead to a valve box and strainer, fitted as before specified for the suctions to the fire and bilge pumps. The lower ends of all bilge-suction pipes will be of galvanized iron. Care will be taken that all the copper bilge pipes are led sufficiently high to keep them out of the bilge water under ordinary circumstances.

78. Engine-room Pumps.—There will be in each engine room two pumps, each capable of discharging 350 gallons per minute. One of these will be fitted as a fire and bilge pump, and the other as a fire and bilge pump and auxiliary feed pump; both pumps will discharge overboard and into the fire main and the latter in addition will discharge into the auxiliary feed pipe.

Both of these 350-gallon pumps will draw water from the bilge as before specified and from the sea.

In addition the auxiliary feed pump will draw from the feed tanks and from the air pump channel ways or suction pipes.

There will also be in each engine room a water service pump of 200 gallons per minute capacity discharging into the fire main, water service, and outboard. It will draw water from the sea only.

In addition there will be in each engine room an auxiliary circulating pump for the auxiliary condenser, discharging into an independent outboard delivery or into the main outboard delivery. This pump will draw from the sea only. It may be centrifugal or direct acting at the option of the contractor, but must be of sufficient size to supply the necessary condensation water for the auxiliary condenser.

79. Engine-room Water Service.—There will be in each engine room for each engine a 4-inch pipe connected with a sea valve and with a special delivery from the auxiliary pump, with branches leading to the different parts of its engine, as follows:

A 1¼-inch branch connected by a union joint with a pipe screwed into the cap of each crank-shaft bearing, and leading through brasses to top of journal;

Two 1¼-inch pipes to each crank pin ;
Two 1-inch pipes to each crosshead ;
One 1-inch pipe to each go-ahead crosshead guide ;
One 1-inch pipe to each pair of eccentrics ;
One 1½-inch pipe to each thrust bearing ;
One 1-inch pipe to each line-shaft bearing ;
One 1-inch pipe to each hollow brass or its equivalent in crank-shaft bearings ;
Two 1-inch pipes to each air-pump engine and to each circulating-pump engine.

All of the above to have detachable sprays or short lengths of hose, as directed, and where directed to have pivoted nozzles. The water service pumps will have a connection to stern tubes as before specified.

Each branch will have a separate valve.

All the water-service pipes and fittings will be of brass ; those above the floors will be polished.

80. Turning Engines and Gear.—There will be in each engine room a double engine of suitable size, to be approved by the Bureau of Steam Engineering, for turning the main engines with steam of 60 pounds pressure. This engine will drive by worm gearing a second worm, which may be made at will to mesh with a worm wheel on the propelling shaft. The worm wheel of each engine will be fitted where directed.

The turning-engine shaft will be squared at the end and fitted with a ratchet wrench, of approved design, for turning by hand.

Each turning engine will have piston valves, and will be made reversible by means of a change valve moved by a screw and hand wheel.

The turning wheels will be of cast steel with cut teeth.

81. Securing Engines in Vessel.—The engines will be adjusted and aligned upon the engine keelsons, and when accurately in line snugly fitting wrought-iron washers or horseshoes will be fitted around all holding-down bolts. The holding-down bolts will be firmly set up and bolts and nuts locked in place.

When finally secured all shafting must be accurately in line with the vessel at load draft and ordinary stowage.

All parts of machinery and boilers will be secured in an approved manner to prevent displacement when the vessel is used for ramming.

82. Steam and Vacuum Gauges.—There will be the following gauges, in polished brass cases, suitably engraved to show to what they are connected—all to be of approved pattern, having seamless double Bourdon tubes:

One on each single-ended boiler;

Two on each double-ended boiler, one at each end;

One connected to each main steam pipe in each engine room;

One connected to each intermediate valve chest;

One connected to each low-pressure valve chest;

One connected to each condenser.

All the above will have 8½-inch dials—those in engine room to be at the working platforms.

Also the following, with 4½-inch dials:

One connected to each intermediate-pressure cylinder jacket;

One connected to each low-pressure cylinder jacket;

One on each auxiliary steam pipe in each engine room and each fire room;

One on each circuit of radiator pipes near the reducing valve.

The gauges on valve chests and steam jackets will be plainly marked with the limit of pressure permissible. The gauges on intermediate and low pressure valve chests will indicate both pressure and vacuum.

A mercurial vacuum gauge will be connected to each condenser.

83. Thermometers.—There will be the following thermometers, all to be permanent fixtures, protected by brass covers, the casings and fittings to be of polished brass:

One on each hot well;

One on each feed tank;

One on each main feed pipe in fire room;
One on each main injection pipe;
One on each main outboard-delivery pipe;
One on each main steam pipe close to engine.

The hot well and feed thermometers will be so fitted as to waste no feed water. With the exception of that on the steam pipe, the above instruments will be metallic dial thermometers. There will also be furnished—

Four spare water thermometers complete;
Six spare steam thermometers complete;

Two standardized thermometers, graduated on stem and reading to 1 degree Farenheit; stems to be at least 20 inches long; each thermometer to be in a rubber-lined brass case, and each case to be suspended by springs in a suitable permanent locked case in engine room. These thermometers must be equal to the best in the market, subject to the approval of the Bureau of Steam Engineering, and be accompanied by certificates of standardization.

84. Revolution Counters.—They will be of an improved type, to register from 1 to 1,000,000, each worked by positive motion; each to be in a polished brass case. There will be fitted—

One for each main engine;
One for each air pump;
One for each circulating pump.

85. Revolution Indicators.—They will be of such approved pattern as shall not be affected to a perceptible degree by the motion of the ship or by changes of temperature. They must be worked off the engines by positive motions, and must be so fitted that changes of engine speed shall not produce violent fluctuations of the indices. There will be two in each engine room, one to show the speed of each propeller.

Approved tell-tales, to be approved by the Bureau of Steam Engineering, will be fitted on the bridge and in the conning tower, to show the direction of the revolution of the main engines.

86. Engine-room Telegraphs.—A repeating telegraph of approved pattern will be fitted in each engine room with its dial at the working platform, and connected to transmitters in conning tower, in wheel house, and on bridge. The connections are to be made in such manner that the chance of derangement shall be minimized.

87. Speaking Tubes.—They will be made of copper or brass not less than No. 20, B. W. G. They will connect each engine room with each fire room; the engine rooms with each other; the fire rooms with each other; each engine room to the pilot house, conning tower, bridge, and to the chief engineer's room; each fire room with the upper deck close to the top of the ash hoist, and elsewhere as required. Each tube will be fitted at each end with a mouthpiece and approved annunciator; the mouthpieces to be connected to short flexible pipes, where required. All mouthpieces or pipes will be plainly marked. The tubes will be suitably cased where necessary.

88. Engine Indicators.—An indicator connection will be made to each end of each cylinder of main engines, and to each end of each steam and water cylinder of each air pump as near as possible to the bore of the cylinder, and so as to be easily accessible. The indicator cocks will be so fitted on each cylinder of the main engines that the indicators may be so placed as to be connected to but one end of the cylinder, or so as to be connected to both ends; the arrangement to be approved by the Bureau of Steam Engineering.

The connecting pipes will be 1-inch bore for the main engines and ¾-inch for the auxiliaries, with easy bends. The indicator motion of each engine and air pump will be so fitted that both indicators on its cylinder can be connected at the same time. The motions of the indicator barrels must be accurately coincident with the motion of the corresponding pistons, and such as to give a motion of not less than 4 inches for the main engines, and 3 inches for the quick-working auxiliaries. The steam cylinders of all auxiliary engines will have holes

tapped for indicator fittings, and then plugged. These engines will have portable indicator motions fitted, then removed and suitably marked and stowed. Where auxiliary engines are duplicated, but one set of indicator-motion fittings need be supplied for all of each kind.

Four indicators will be furnished for each engine room; one for the high-pressure cylinder, with two springs of 80 pounds, one of 60 pounds, and one of 40 pounds to the inch; one for the intermediate-pressure cylinders, with two springs of 40 pounds and two of 30 pounds to the inch; two for the low-pressure cylinders, each with two springs of 20 pounds and two of 10 pounds to the inch; and three indicators for auxiliary engines, each with two springs of 80 pounds, one of 60 and one of 40 pounds to the inch.

The indicators will be the best in the market, all of the same manufacture and size, and with interchangeable springs, subject to the approval of the Bureau of Steam Engineering, with detent motion, and will have adjustable tension to the barrel spring. They will be nickel-plated, and will be complete with all attachments. One extra cock attachment will be furnished with each indicator. Each indicator will be in a separate locked case, each case to be conveniently stowed.

89. Engine-room Desks.—A black-walnut desk of approved pattern, with locked drawers, and with a locked cabinet of pigeon holes, will be fitted in each engine room where directed.

90. Clocks.—There will be in each engine room, close to the counter, in a polished brass case, an eight-day clock, with 8½-inch dial and a second hand. The pattern and movement to be approved by the Bureau of Steam Engineering.

There will be in each fire room a similar clock, with an outer dust-tight case with heavy plate glass.

91. Boilers.—There will be three double-ended main boilers, and two single-ended boilers for either main or auxiliary purposes, of the horizontal return fire-tube type, all to be made of steel. All the boilers will be about 16

feet 9 inches outside diameter. One of the double-ended boilers will be about 21 feet long and the other two will be about 19 feet long. The single-ended boilers will be about 9 feet 10½ inches long. They will have for the double-ended boilers about 18,147 feet of heating surface and about 567 square feet of grate surface. The single-ended boilers will have a total of about 5,804 square feet of heating surface and about 189 square feet of grate surface. Each double-ended boiler will have eight corrugated furnace flues, 3 feet 6 inches internal diameter, and each single-ended boiler will have four corrugated furnace flues, 3 feet 6 inches internal diameter.

92. Boiler Material.—All plates used in the construction of the boilers will be open-hearth steel. The rivets will be of open-hearth or Clapp-Griffith's steel. All material will be tested, as elsewhere specified.

93. Boiler Shells.—For the double-ended boilers they will be of three and for the single-ended boilers of one course, each course of three plates $1\frac{27}{64}$ inches thick.

94. Boiler Heads.—Both heads for the double-ended boilers will be made of three plates. The upper plate will be $1\frac{27}{64}$ inches thick, the middle plate ⅞ inch thick, and the bottom plate ¾ inch thick.

The front head of the single-ended boiler will be made of the same number and thickness of plates as the double-ended boilers; the back head will be made of three plates, the upper plate will be $1\frac{27}{64}$ inches thick and the other ¾ inch thick.

The upper plate of each head of the boilers will be curved back to a radius of about 4 feet.

The heads of all the boilers will be flanged outwardly at the furnaces and inwardly at the circumference. The heads will be stiffened by angle or **T** bars, as shown on drawings.

95. Boiler-tube Sheets.—For all the boilers they will be ⅞ inch thick at the front and ¾ inch thick at the back. Each pair of tube sheets must be accurately parallel. All tube holes will be slightly rounded at the edges. The

holes for stay tubes will be tapped in place. The holes at combustion-chamber end will be drilled to suit the protection of tubes, as specified below.

96. Boiler Tubes.—They will be of steel, lap-welded and drawn, the best that can be obtained in the market, and subject to the approval of the Bureau of Steam Engineering. All tubes will be 2¼ inches external diameter. The ordinary tubes will be No. 12, B. W. G., in thickness, and will be swelled to $2\frac{5}{16}$ inches external diameter at the front ends for all boilers. The back ends will be expanded in the tube sheet, beaded over into a counter bore, which will be filled with a ring, or they will be protected from the action of the flame in other approved manner. The method of protection must be such as will meet with the approval of the Navy Department.

The stay tubes will be No. 6, B. W. G., in thickness. They will be reinforced at both ends to an external diameter of 2⅜ inches, leaving the bore of the tube uniform from end to end. They will then be swelled at the front ends to 2½ inches external diameter. They will be threaded parallel at combustion-chamber ends, and taper at front ends to fit threads in tube sheets. They will be screwed into the tube sheets to a tight joint at the front ends, and will be made tight at the back ends by expanding and beading. All expanding will be done by approved tools. Cast-iron ferrules of 1½ inches internal diameter will be used to protect the ends of stay tubes in combustion chambers. All tubes will be spaced 3¼ inches from center to center vertically, and 3½ inches horizontally. If directed, the tubes shall be finished according to designs furnished by the Navy Department.

97. Combustion Chambers.—There will be four combustion chambers in each double-ended boiler and two in each auxiliary boiler. The combustion chambers will be arranged so that there will be one combustion chamber for each two adjacent furnaces. They will be made of ½-inch plates, except the tube sheets, which will be as before specified. The tops of the combustion chambers will be braced by girders, as shown. The plates will be

flanged where necessary, and all parts joined by single riveting. The holes for screw stay bolts in plates of combustion chambers and shells will be drilled and tapped together in place.

98. Boiler Bracing.—The bracing will be as shown in drawings.

The combustion chambers will be stayed to each other and to the shell of the boiler by screw stays, screwed into both sheets and fitted with nuts—the nuts to be set up on beveled washers where stays do not come square with the plates. The holes for screw stays will be tapped in both sheets in place.

The nuts for the upper longitudinal braces will be forged or cast steel with a flange as shown. The thread will be cut away on the outside of the nut forming a chamfer. When the nut is set up to place, the rivet holes will be drilled in the head and the nut riveted to it and calked around the edges and the end of the brace riveted over into the nut.

The bottom of the combustion chambers will be stiffened by angles.

All screw stays and all screwed braces will have raised threads.

All braces will be made without welds.

In boiler braces fitted with eyes, care must be taken that the sectional area through the neck or eye is not less than that of the cylindrical portion.

99. Riveted Joints.—The longitudinal joints of boiler shells will be butted, with 1¼-inch straps outside and $1\frac{1}{16}$-inch inside. and treble riveted, as shown on the drawings. Joints of heads with shells will be double riveted; all other circumferential joints will be lapped and treble riveted. Joints in furnaces and combustion chambers will be single riveted. Rivets will be of Clapp-Griffith steel, with heads in accordance with Bureau of Steam Engineering standard. Edges of all plates in cylindrical shells, and of all flat plates where not flanged, will be planed. Edges of flanges will be faired by chipping or otherwise, as may be approved.

Plates in cylindrical shells must not be sheared nearer the finished edge than one-half the thickness of the plate along the circumferential seams, and not nearer than one thickness along the longitudinal seams. No plate must average less than the specified thickness along the longitudinal seams. All rivet holes in shell plates will be drilled in place after bending. Hydraulic riveting will be used wherever possible. In parts where hydraulic riveting cannot be used, the rivet holes will be coned and conical rivets used. Seams will be calked on both sides in an approved manner. Longitudinal seams will break joints. All joints will be as shown on drawings.

100. Boiler Manholes and Hand-holes.—There will be manholes in each boiler, placed, and of such size, as shown in drawing.

All manholes will have stiffening rings. The upper manhole will have raised cast-steel frame flanged and riveted to the inside of the shell of the boiler, as shown.

The manhole covers will be of mild steel and stamped in dished form. All manhole plates will be secured by two wrought-iron dogs and two 1¼-inch studs with square nuts. Each plate will have convenient handles.

All plates, dogs, and nuts will be indelibly marked to show to what holes they belong.

101. Furnaces.—Each furnace will be in one piece, $\frac{9}{16}$ inch thick, and corrugated, 3 feet 6 inches least internal diameter and 3 feet 10 inches greatest external diameter. They must be perfectly circular in cross section at all points. They will be riveted to flanges of front heads, and will be flanged and riveted to combustion-chamber plates. The corrugations of adjacent furnaces will be made to alternate.

102. Grate Bars and Bearers.—The grate bars will be of wrought iron or of approved shaking pattern as directed. They will be so fitted that they can be readily worked under forced draft without opening the furnace or ash-pit doors, and without allowing an escape of air or gases. They will also be so fitted as to be readily removed and

replaced without hauling fires. The bars at sides of furnaces will be made of cast iron to fit the corrugations. The bearers will be made of wrought iron, supported by wrought-iron lugs bolted to the furnace flues, and perforated so as to allow the air to reach all parts of the grate bars.

103. Bridge Walls.—They will be made of cast iron, so fitted as to be readily removable. They will extend back to the back of combustion chambers so as to leave no place behind them where dirt can accumulate. They will be finished with fire brick or other approved refractory material.

104. Furnace Fronts.—They will be made with double walls of wrought iron, bolted to a light frame. The space between the two walls will be in communication with the ash pits or fire room if closed fire-room draft is used. The upper part of the inner plate of furnace fronts will be perforated as directed. The dead plates will be made of cast iron, and fitted so as to be easily removed and replaced. The door openings will be as large as practicable. There will be a beading on the inside of the door frame in wake of the inner plate of door to make the clearance as small as possible.

105. Furnace Doors.—The furnace doors must be protected in an approved manner from the heat of the fire. There will be three hinges to each door, all of wrought iron; the upper hinge will be so made as to support the weight of the free end of the door, and so fitted that the sag can be easily taken up. The latches will be of wrought iron. Drawings showing the arrangement of furnace fronts and furnace doors must be submitted to the Bureau of Steam Engineering before work is commenced on them.

106. Air Ducts.—Air ducts, as shown on the drawings, will be fitted to supply air for the fire-room blowers. Hoods or screens must be fitted so as to prevent the hot air arising through the fire-room hatches being drawn down the ducts leading to the blowers. Each air duct

leading to a blower will be fitted with a damper, which can be easily and quickly closed in case its blower is stopped. The ducts will be constructed of iron or steel plates not less than $\frac{3}{16}$ inch thick.

107. Ash-pit Doors. — They will be made of $\frac{1}{8}$-inch wrought iron, stiffened with angle or channel iron. Each door will have two wrought-iron handles and two wrought-iron beckets to fit hooks on uptake doors.

108. Lazy Bars.—A portable lazy bar with the necessary lugs will be fitted in front of each ash pit. Also portable lazy bars for the furnaces.

109. Ash Pans.—Ash pans of $\frac{1}{4}$-inch wrought iron, reaching from the front of furnace flue to bridge wall, will be fitted to all furnaces.

110. Circulating Plates.—Each boiler will have circulating plates fitted at each side of each nest of tubes. They will be of steel, $\frac{1}{8}$ inch thick, in sections, so as to be easily introduced and removed through manholes. Each section will have two clips at upper and one at lower end for supporting it from the stay tubes. The plates will be well painted all over with two coats of approved paint or cement.

111. Uptakes.—They will be of three thicknesses, of wrought iron or steel, double-spaced, built on angle, channel, or **Z** bars, and they will be bolted to the boiler heads and shells. The inside sheet will be No. 8, B. W. G., and will be bolted to the lower part of the smoke-pipe, having oval holes to allow for expansion.

The space between the two sheets will be two inches and will be closed at the bottom, and will be in communication with the space between the smoke pipe and its casing. There will be dampers arranged near the bottom of the air space to allow of escape of heated air from the fireroom when under natural draft.

Outside the double uptake there will be a sheet of No. 12, B. W. G., iron or steel, making in all three thicknesses of iron or steel. This latter sheet will have a space of 2 inches between it and the middle sheet, and will extend

from the top of the dampers to within 6 inches of the protective deck. This 2-inch space will be filled with magnesia or an approved non-conducting substance.

112. Uptake Doors.—The uptake doors will be made in a similar manner to the uptakes as before described, but in addition they will be fitted with a "baffle" plate of No. 10, B. W. G., stayed 2 inches from the inner sheet of the door.

The hinges and latches will be made of cast or wrought steel or wrought iron. The doors must be hung so that they will swing out in line with the tubes without interference. Each door will have two hooks for hanging the ash-pit doors on, and a hook for a tricing rope.

113. Smokepipes.—There will be two smokepipes, each about 100 feet in height above grate of the lower furnaces.

The pipe will come through the protective deck in two square parts, each part connecting with the uptake. These parts will join above the top of the longitudinal bulkhead into a square shape, which will run into a round section at the gun deck. The weight of the pipe will be taken on the protective deck, the parts of the pipe passing through this deck being of ½-inch plate, spaced about 2⅜ inches apart, and secured to each other by channeled or Z bars. Inside the inner sheets will be a ledge supporting the armor bars. The outer plate will be connected to the protective deck by angle bars which must be of sufficient strength to support the whole pipe. The two inner sheets of the uptake will be secured to these plates as before specified, with oval holes to allow for expansion. From the double plates fastened to the protective deck, the pipe will be carried up to the gun deck formed of two ¼-inch plates, spaced 2½ inches apart, and well stayed on the outside by angle or T-iron, and connected by vertical Z or channel iron. This spacing will be carried to the top of the pipe. Outside of the pipe, between the protective deck and gun deck, there will be a covering plate, No. 12, B. W. G., stayed or thimbled 2-inches off, the space being filled with magnesia or approved non-conducting material.

The lower half of the round inner pipe will be made of No. 7, B. W. G., iron or steel, and the upper half of No. 9, B. W. G. It will be finished at the top by angle bars. It will also have a hood to which stay shackles will be secured for slinging painters. It will extend down over the outer pipe, leaving a sufficient area for the escape of the heated air. The outer pipe will be of No. 12, B. W. G., strongly stayed to the inner. It will be butted and strapped on the inside and flush-riveted on the outside. It will extend within about 6 inches of the hood at the top.

The pipes will be stayed by three rows of guys and turnbuckles, one row near the top of the inner casing, one row about 30 feet from the deck, and the other row about halfway between the two. There will be four guys in the upper row, two in the second row, and four in the lower row. The guys will lead fore and aft, and athwartships in the upper and lower rows and athwartships only in the center row.

The shackle bolts will extend through both pipes, passing through a thimble between them, having a nut on the inside, with collar on the outside. There will also be a band around the pipe at each row of guys 6 inches by ¼ inch, riveted to outside casing.

From the gun deck to 6 feet above it, there will be a casing surrounding the outer pipe and 6 inches from it, of No. 12, B. W. G. Above the top of the casing will be an umbrella and curtain, finished on the edge with half-round iron, to prevent water coming down the casing, and leaving space sufficient for the exit of the air.

There will be a ladder on the outside of each pipe on the forward side, extending to the top. This ladder to be made of round iron, bent and riveted to the pipe.

There will be doors through the casings and pipes, about on a level of the berth deck, large enough to admit a man.

114. Smokepipe Covers.—If directed the smokepipes will have permanently fixed covers made of wrought iron No. 11, B. W. G., built on angles in a slightly dished form and supported by angles riveted to the smokepipes. The covers will be placed at such a height above the top of

the smokepipes so that they will not interfere with the escape of the gases, and will overlap the smokepipes about 21 inches all around.

115. Boiler Saddles.—The boilers will be supported by lugs of plate steel or iron, 1⅜ x 12 inches, with the ends brought together and welded into a triangular shape, the hypothenuse being bent to fit the boiler, and the base resting on a continuous keelson or shelf built in the ship. Each lug will be bolted to the boiler by six 1⅜-inch bolts extending through the shell and having a nut on the inside and also tapped into the shell.

Each lug will be bolted to the keelson by four 1⅜-inch bolts. There will be ten of these lugs on each double-ended boiler and six for each single-ended boiler; the center lug will be bolted to the keelson by fitted or driven bolts, and the others will have oval holes to allow for expansion.

116. Boiler Attachments.—Each boiler will have the following attachments, viz:

One steam stop valve;

One dry pipe;

One main feed-check valve with internal pipe;

One auxiliary feed-check valve with internal pipe;

One bottom blow valve with internal pipe;

One surface blow valve with internal pipe and scum pan;

Two safety valves to be connected with dry pipe or have internal pipes;

One steam gauge on each single-ended boiler, and one at each end of each double-ended boiler;

Two glass water gauges of approved automatic closing pattern on each single-ended boiler, and two at the feeding and one at the other end of each double-ended boiler;

Four gauge cocks on each single-ended boiler, and four at each end of each double-ended boiler;

One sentinel valve;

One salinometer pot;

One drain cock;

One air cock;

One approved circulating apparatus;

One cock with thread for the attachment of a syringe.

All external fittings will be of composition unless otherwise directed. All fittings will be flanged and through-bolted or attached in other approved manner. All cocks, valves, and pipes will have spigots or nipples passing through the boiler plates. All internal pipes will be of brass, No. 14, B. W. G., and must touch the plates nowhere except where they connect with their external fittings. The internal feed and blow pipes will be expanded in the holes in boiler shells to fit the nipples on their valves, and they will be supported where necessary in an approved manner. The stems of all valves on boilers are to have outside screw threads. The internal feed and blow pipes are to be arranged to come between the corrugations of furnaces.

117. Boiler Main Stop Valves.—There will be a 10½-inch self-closing stop valve, with horizontal spindle, on each double-ended boiler, and one 7½ inches diameter on each auxiliary boiler. There will be a 7-inch nozzle on each valve chamber of the double-ended boilers for attachment of the auxiliary stop valve.

A screw sleeve, with suitable hand wheel, will be fitted for closing the valve; also a spindle and handle for opening the valve.

The stop valves on all the boilers will be located as directed.

The wheels on all boiler stop valves will have rims covered with wood.

118. Boiler Auxiliary Stop Valves.—There will be on each of the double-ended boilers a 7-inch self-closing stop valve, with horizontal spindle bolted to a nozzle on the main stop-valve chamber.

119. Dry Pipes.—There will be in each boiler, as high as possible, and properly supported, a brass or tinned copper dry pipe, extending nearly the length of the boiler, perforated on its upper side with longitudinal slits of such a number and size that the sum of their areas will equal seven-eighths of the area of the stop valve. The pipes will be 12 and 9 inches diameters, respectively, for the double-ended boilers and auxiliary boilers.

120. Feed-check Valves.—The main and auxiliary check valves on the double-ended boilers will each be 4½ inches in diameter, and on the auxiliary boilers 3 inches diameter. They will be placed on the shell at front ends of the boilers, but entirely separate from each other, and will be fitted with internal pipes, the main feed pipes leading above the tubes and pointing downward in the water spaces between the nests of the tubes and between one of the wing nests and shell, as shown. The auxiliary internal feed pipe will lead in a similar manner on the other side of the boiler.

The valve cases will be so made that the bottom of the outlet nozzle shall be at least ½ inch above the valve seat. The valves will be assisted in closing by phosphor-bronze spiral springs. These valves will have polished brass bent bar handles in lieu of hand wheels.

The feed-check valves will have stop valves between the check valve and the boiler.

121. Safety Valves.—Each double-ended boiler will have four 5-inch, and each single-ended boiler two 5-inch spring safety valves, placed on the stop valve nozzles, two valves to be in one case.

Each valve will have a projecting lip and an adjustable ring for increasing the pressure on the valve when lifted, or an equivalent device for attaining the same result. They will be adjustable for pressure up to the test pressure—the adjusting mechanism to have an index to show the pressure at which the valve is set, and a lock to prevent tampering with the adjustment. The locks on all safety valves will be alike. The springs will be square in cross section, of first quality tool steel, and will be nickel-plated. They will be of such a length as to allow the valves to lift one-eighth of their diameters when the valves are set at 160 pounds pressure. They will have spherical bearings at ends, or be connected to the compression plates in such a manner as to insure a proper distribution of pressure. They will be inclosed in cases so arranged that steam will not come in contact with the springs. The spring cases will be so fitted that the valves can be removed without slacking the springs.

The valve stems will fit loosely in valves, to bottom below the level of the seats, and to be so secured that the valves may be turned by a wrench or cross-bar on top of stem. The valves will be guided by wings below and in an approved manner above. The valves will be fitted with mechanism for lifting by hand from main deck and fire rooms, the mechanism for each pair of valves to be such that the valves will be lifted in succession. All joints in the lifting gear will be composition-bushed. The outlet nozzle will be in the base casting, so that the joint at the escape pipe will not have to be broken when taking the valves out. The casings, valves, and spindles will be made of composition. The valve seats will be of nickel or equivalent metal of approved kind. A drain-pipe will be attached to each safety-valve casing below the level of the valve seats, leading to the bilge.

122. Sentinel Valves.—Each boiler will have a sentinel valve of ½ square inch area. It will have a sliding weight on a notched lever graduated to 175 pounds pressure, and will be placed at the same end of the boilers as the check valves.

123. Bottom-blow Valves.—There will be a 2½-inch bottom blow valve on each boiler, bolted to the shell near the front. The valves will close with the boiler pressure. An internal pipe will lead from each valve to near the bottom of the boiler.

124. Surface-blow Valves.—There will be a 2-inch surface blow valve on each boiler, bolted on or near the front. The boiler pressure will be above the valve. An internal pipe will lead from each valve to near the water line in the boiler, and will be fitted with a scum pan. The valve casing and hand wheel will be of composition.

125. Blow Pipes.—A 3-inch pipe will connect with all bottom blow valves in each compartment and with a sea valve in the same compartment. This pipe will have a nozzle for the connection of a pipe for pumping out the boilers, as well as 2-inch nozzles for attachment of pipes from the surface blow valves. There will be a straight-

way valve in the blow pipe as near the sea valve as possible.

All joints will be flange joints.

126. Boiler Pumping-out Pipes.—A 3-inch pipe will connect the bottom blow pipe in each compartment with one of the auxiliary feed pumps, with a screw-stop valve above the floor near the pump.

127. Steam Gauges.—There will be a spring steam gauge on each auxiliary boiler and one at each end of each double-ended boiler. The gauges will have seamless tubes and 8½-inch dials, graduated to 255 pounds, and will have the double Bourdon tube. This gauge will have an independent connection with the boiler and be fitted with a three-way cock, a drain cock at the lowest part of the steam pipe from the boiler, and a coupling for attachment of a test gauge.

128. Boiler Water Gauges.—Each auxiliary boiler will have two glass water gauges, and each double-ended boiler will have two glass water gauges at the feeding and one at the other end, and all to be of approved automatic closing pattern. Each gauge will be placed at the side of the boiler and will have 1½-inch pipes leading to top and near bottom of boiler, with a valve in each close to boiler, the two gauges at the same end being placed on opposite sides and as far apart as possible. The shut-off and blow-out cocks are each to have at least ¼ inch in diameter clear opening, and will have levers and rods for working from fire room. The glasses will be about 16 inches in exposed length, with the lowest exposed part about 1 inch above the highest heating surface. They will be ¾ inch outside diameter. The glasses will be well protected. A brass index plate, with letters and arrows cast in relief, will be fixed close to each gauge glass to show the height of the top of combustion chamber. The blow-out cocks will have drainpipes leading to bilge with union joints, ½ inch inside diameter.

129. Gauge Cocks.—There will be four gauge cocks or valves on each single-ended boiler and four on each end of each double-ended boiler. The valve chambers will have

two seats, the inner one formed in the casting and the other movable, screwed into the casting and furnished with a handle. The valve will have two faces, and will be closed by screwing down the movable seat and will be opened by the pressure in the boiler when the outside seat is slackened off. There will be a guide stem on each side of the valve, the valve and stem being turned from one piece of rolled manganese bronze or Tobin's metal; the stem on the inner side being square and also on the outside of the outer seat to ¾ inch beyond it. It will be of a circular section where it passes through the movable seat. The opening of the valve will be at least ⅜ inch in diameter, and the discharge from the chamber will be at least ¼ inch diameter. They will be provided with rods and levers for working from fire room. Each cock will be independently attached to the boiler. They will be spaced about 6 inches vertically, the lowest one being about 4 inches below the highest heating surface.

Each set will have a drip pan and a 1-inch copper or brass drainpipe leading to the bilge.

The castings will be sufficiently strong to avoid breakage under ordinary circumstances.

130. Salinometer Pots.—There will be a salinometer pot of approved pattern connected to each boiler. They will be placed in groups in the fire rooms where directed.

131. Boiler Drain Cocks.—Each boiler will have a 1-inch drain cock of approved pattern.

132. Boiler Air Cocks.—Each main boiler will have a ½-inch air cock at its highest part, with a ½-inch copper pipe leading to bilge.

133. Circulating Apparatus.—There will be fitted to each boiler an approved device for circulating the water in the boiler while raising steam. Each of these will be fitted where directed and have a stop valve close to boiler. They will take steam from the auxiliary steam pipe, with stop valve in fire room.

134. Zinc Boiler Protectors.—Each boiler will have rolled zinc plates, 12 x 6 x ½ inch. Each plate will be bolted to

wrought-iron straps, which will be clamped to the stays. Each strap will be filed bright where in contact with zinc and stay, each stay being also filed bright at contact point. After being bolted in place the outside of the joints will be made water-tight by paint or approved cement. The zinc plates will be located as may be designated by the Bureau of Steam Engineering, and there will be 1½ square feet of exposed surface exclusive of edges for each 100 square feet of heating surface in the boilers.

Surrounding the zinc and bolted to the stay will be placed baskets of ⅛-inch steel plate to catch the zinc when disintegrated. The baskets will have six ⅝-inch holes in the bottom.

135. Main and Auxiliary Feed Pumps.—There will be in each fire room in which check valves are placed, viz: The forward fire rooms of the after boilers, the fire rooms of the forward auxiliary, and the after fire room of the forward boilers, the following pumps:

In the port after boilers forward fire room a main feed pump capable of delivering 350 gallons per minute; in the starboard fire room an auxiliary pump capable of delivering 350 gallons per minute;

In the port after fire room of the forward boiler, a main feed pump, capable of delivering 350 gallons per minute and an auxiliary pump in the starboard fire room, capable of delivering 260 gallons per minute;

In the starboard forward fire room an auxiliary pump, capable of delivering 90 gallons per minute;

The capacity of the main feed pumps will be calculated on 100 feet per minute, piston speed, and 75 per cent. efficiency.

The auxiliary pumps and those pumps drawing from the sea will be estimated at 100 feet piston speed and 100 per cent. efficiency.

In the above pumps the water valves will be metallic of approved kind. The pumps will be so arranged that the packing of the water cylinders will be easily accessible. The steam cylinder must be of sufficient size to

work the pump at the required speed to supply the water above required.

The exhaust cushion must be adjustable. The water cylinders, pistons, and pumps, and pump rods will be of composition or bronze, and all other working parts will be of wrought iron or steel. The water cylinders will have a removable lining for convenience in reboring.

Each main feed pump will draw water from the feed tanks only and deliver into the main feed pipe only.

Each auxiliary feed pump will be arranged to draw from the main feed tanks, the sea, the bilge, or the boilers, at will, and to discharge into the boilers through the auxiliary feed valves, into the fire main or overboard through the outboard delivery of its own compartment. Auxiliary pumps will have steam cylinders sufficiently large to work as fire pumps with steam of 60 pounds pressure.

136. Feed-pump Pressure Gauges.—Each main and auxiliary feed pump will have a spring pressure gauge registering from zero to at least 300 pounds per square inch.

137. Ash Hoists.—One ventilator in each fire room will have vertical guide strips of iron on the inside and be fitted with all the necessary gear for hoisting ashes.

An ash-hoisting engine of approved design will be fitted in each fire-room hatch or such place as may be directed, of sufficient power to hoist 300 pounds from the fire-room floor to the deck in five seconds with steam of 60 pounds pressure.

It will have a reversing gear, to be worked from the fire room and from deck, with approved adjustable safety gear to prevent overwinding and to stop the engine when the ash bucket reaches the fire-room floor. It will also be fitted with an approved brake to control the drum. The ash hoist will be fitted with the necessary sheaves, whip, and all appliances necessary for handling ash buckets.

138. Coal-hoisting Engines.—There will be two coal-hoisting engines capable of lifting 1,000 pounds at 300 feet per minute, located where directed.

139. Fire-room Blowers.—There will be one blower of approved pattern in each fire room.

These blowers must be capable of supplying to the fires continuously, with ease, sufficient air to maintain the maximum rate of combustion. They will take air from ducts, as shown on the drawings, and deliver into the fire rooms. If necessary light iron screens will be fitted in fire rooms so that the air from the blowers will not blow the coal dust.

The spindle bearings must be accessible while the blowers are in motion, and will be of anti-friction metal, fitted in composition boxes, and, together with their lubricating apparatus, must be thoroughly protected from dust.

If the blowers are fitted with casings, the casings must be so made that they can be removed without cutting out rivets.

140. Air-tight Bulkheads.—Light iron bulkheads will be fitted as may be required, so as to limit the space under air pressure. Air-tight doors will be placed in these bulkheads where directed.

141. Ventilating Fans.—There will be two blowers in the engine-room hatch or such place as may be directed, one for each engine room, each capable of delivering 10,000 cubic feet air per minute, for ventilation of the engine rooms. They will take air from ventilators led to such a distance above the hatch that the hot air rising from the hatch will not be drawn down the ventilators. Air ducts will be led from these fans and will be so arranged that the engine rooms and shaft alleys will always be thoroughly ventilated.

Each blower will be driven by an independent engine of the same kind as specified under blower engine.

142. Blower Engines.—Each blower will be driven direct by a balanced engine of two or more cylinders of an approved design and of sufficient power to run the blower at full speed with steam of 100 pounds boiler pressure. The engine valves must be of the slide or piston type.

All working parts must be closed in, but easily accessible for overhauling. The lubrication must be automatic and thorough, and such that the oil cannot come in contact with dust in the fire room. The throttle valve in the steam pipe of each blowing engine will be arranged to be worked from the fire-room floor, with suitable index to show how much it may be open. The steam pipe for each blower will connect with auxiliary steam pipe.

The shafts of blower engines will be so fitted that a portable revolution indicator can be quickly and easily applied without removing any part of the mechanism.

143. Air-pressure Gauges.—A gauge of a pattern approved by the Bureau of Steam Engineering will be fitted in each fire room to show the air pressure.

A portable gauge will also be supplied to each fire room, with convenience for connecting it to the furnaces, uptakes, and wherever it is desired to measure the air pressure.

All these gauges will indicate pressure in inches of water.

144. Air Locks.—Suitable air locks must be provided in the passages into the fire rooms and in the ash-hoist ventilators to prevent the escape of air while the fire rooms are under pressure.

145. Fire-tool Racks.—Racks will be fitted in each fire room in convenient places for holding all necessary fire tools.

146. Ash Dumps.—From each ash hoist, on the upper deck, permanent overhead rails, suitably supported, will lead to the nearest ash chute on each side of the ship, if directed. Each of these will be fitted with a traveler of approved design, with all necessary appliances for carrying the ash buckets. At the top of each ash chute a dumping hopper of approved design will be fitted, so arranged as to fold up out of the way when not in use. Arrangements must also be made, either by a temporary chute or other approved manner, for dumping ashes from either side into a lighter. The ash buckets are to be

balanced dump buckets, with all necessary gear complete. All the ash hoisting and dumping gear will be such that the buckets will not have to be lifted by hand.

147. Ash Sprinklers.—A valve for wetting down ashes will be fitted in each fire room, where directed, and will be fitted with all necessary hose, couplings, nozzles, and reels or racks.

148. Steam Tube Cleaners.—A steam tube cleaner of approved design will be fitted in each fire room. Steam will be taken from the auxiliary steam pipe. Sufficient length of steam hose will be provided to easily reach all the tubes.

149. Gun-table or Turret-turning Gear.—The gun tables or turrets for the 8-inch guns will be revolved by means of worm gearing connected to the bottom of the ammunition tube, and driven by a steam engine situated as shown in the drawing to be furnished the contractor. The engine will be controlled by hand wheels, situated at the sighting stations in the turrets, by means of suitable gearing extending down the inside of the ammunition tube, and connecting with a reversing valve which changes the steam and exhaust ports of the engine, and so arranged that the turret follows the movement of the hand wheel.

The engines will be of approved type—collectively of sufficient power to turn the gun table or turret at the rate of one revolution per minute, with the guns run out and the vessel heeled 10 degrees, with a steam pressure of 100 pounds per square inch. The turning engines must have all their parts easily accessible. The engines will be arranged to reverse by changing the steam and exhaust ports, and to run equally well in either direction. They will be of the double-cylinder type, with the cranks placed at right angles. Two cast-steel bevel gears on the crank shaft will drive the two screw shafts, which, acting on the worm wheel at the base of the ammunition tube, turns the turret.

The worms will be of cast steel with cut teeth, and finished all over. Provision will be made for disconnecting the worms by backing out a cross key and sliding

the worms along the shaft out of reach of the worm wheel.

The worm wheel will consist of a cast-steel ring having cut teeth and bored out conically to a diameter sufficiently large to allow a conical composition friction ring to be inserted between the worm wheel and a composition sleeve which encases the lower end of the ammunition tube. This friction ring will be bored out to fit the sleeve and turned conically to fit the inside of the worm wheel and then cut. It will be fitted with studs and adjusting nuts so the friction can be regulated as desired. A suitable flange on the sleeve will keep the worm wheel in place.

A composition trough will be placed under each worm and so arranged that when filled the teeth of the worm will dip into the oil. Drip pans will be placed where necessary to prevent the oil and water from dripping on the deck. The cylinders will be provided with ample drains leading to the exhaust-steam pipe. Cocks will be fitted in the drains close to the cylinders.

The engines will be started, stopped, and reversed by a balanced valve which changes the steam and exhaust ports. This valve will be moved by a screw working in a crosshead as shown. The screw is turned by means of a sector attached to an annular gear wheel which travels freely on the top of the worm wheel. It is geared to a vertical shaft extending up the inside of the ammunition tube and carrying a worm wheel on its top, which in turn is connected by suitable gearing to hand wheels placed at the sighting stations in the turret. Any movement of the hand wheels will change the position of the reversing valve, causing the engines to turn the turret and with it the handling gear, the direction being so as to close the valve and bring the turret to rest. Stops will be placed on the annular gear wheel to prevent the gear being turned too far and jamming the valve.

The top of the vertical shaft is terminated by a worm gear wheel, which is held in its place on the shaft by a conical jam nut and which is to be released when the turret is turned by hand, allowing the shaft to revolve

freely, as it must, the annular gear wheel being held by stops.

The hand wheels for moving the valve gear are two in number, one at each sighting station in the turret, and are so geared that one turn of the hand wheel moves the turret about 10 degrees.

An unhooking gear permits the valve to be worked by hand from the lower deck in the event of the handling gear in the turret being disabled, a lever for working the reversing valve being provided for that purpose.

The ammunition tube by which the turret is turned is cut in two, leaving a space of ½ inch between the sections. A coupling is formed of cast steel on the same principle as an ordinary clutch coupling, only the spaces between the faces are filled with two plates of pure gum 1½ inches thick, with steel or iron plates between them. This is intended to ease the shock of the recoil of the gun on the worm gear. The pressure will be regulated by compressing the gum as much as it would be when turning the turret with the guns run out fore and aft with the ship heeled 10 degrees.

The conical friction ring between the worm wheel and the sleeve around the base of the ammunition tube will be adjusted so that the turret can be turned when at its greatest resistance. It is designed to prevent too great a strain being thrown on the worm gearing when the gun is fired.

Stops will be placed on the ammunition tube to prevent the turret from being turned too far. The turret is not designed to turn all the way around. These stops are to be set in accordance with the angle, to be given by the Bureau of Ordnance, through which the turret is to turn.

The teeth of all gears will be cut. The material of all gears not otherwise specified will be of composition.

Drawings of the turning gear above specified will be furnished hereafter to the contractors.

There will also be an arrangement by which the turret or platform can be turned by hand in case of the disarrangement of the turning engine.

There will also be a locking bolt or clutch for securing the turret or table in any desired position.

If it is hereafter decided by the Navy Department to use hydraulic power for turning the turret, the contractor will substitute that material in lieu of the one above specified, the same requirements being had as in the case of steam, and the necessary hydraulic pumps will be furnished for turning turrets, ordnance purposes, and steering gear if required. In the event of hydraulic power being required, specifications for pumps and turning gear will be furnished by the Bureau of Steam Engineering.

It is not decided yet by the Department what motor is to be used to turn the gun tables or turrets of the 12-inch guns. When the Department decides upon this point, specifications will be furnished for the turning gear and pumping plant for all purposes if an hydraulic motor is used, and if steam is used specifications for that method and for pumping-plant for ordnance purposes and for steering gear.

150. Workshop Machinery.—There will be fitted in the engineer's workshop the following tools, arranged to work by hand and power; to be of the best make and to be approved by the Bureau of Steam Engineering:

1. A back-geared screw-cutting engine lathe; to swing 24 inches over ways and 16½ inches over carriage and take 4 feet between centers. It will be fitted with gear for cutting threads from 2 to 32 to the inch, and with four grade cone pulleys.

It will have a hollow spindle on the driving head, with hole 1½ inches diameter. The carriage will have automatic cross feed. The lathe to be fitted with scroll and drill chucks. Weight not to exceed 4,000 pounds. Bed not to exceed 8 feet in length.

2. A 14-inch, back-geared, screw-cutting engine lathe; to swing 14 inches over bed, 9 inches over carriage, and take 40 inches between centers. To have hollow spindles with ¾-inch holes on driving head, and be fitted with gears to cut from 4 to 64 threads per inch; lead screws to be used for screw cutting only. Lathe to have taper cutting attachment and to be fitted with scroll and drill chucks. Cone pulley to have four steps. Length of bed not to exceed 6 feet.

3. A column-shaping machine, of 12 inches stroke and 19 inches traverse, with vertical adjustment to table and arbor for circular planing ; to have four grade cone pulleys, and be fitted with chuck. Weight not to exceed 2,200 pounds.

4. A double-geared drilling machine with screw feed ; to have three grade cone pulleys, and be capable of drilling from ½-inch to 1½-inch holes ; to have adjustable swinging table ; to drill 18 inches from edge of work.

5. A small iron column bench drilling machine for hand and power, to have three grade cone pulleys ; to drill from ⅛ to ¾ inch holes ; to have automatic feed.

6. A combined hand punch and shears, capable of cutting ¾-inch round iron, shearing ⅜-inch steel plate, and punching ⅜-inch holes in ⅜-inch mild steel plate; shear blades to be 6 inches in length.

A vertical engine, with cylinder 6 x 8 inches, will be provided to drive these tools ; engine will have fly wheel, driving pulley, and automatic governor ; to make about 160 revolutions per minute.

The tools above specified will be erected and fitted where directed in the engineer's workshop. Each machine will be driven from a countershaft with cone pulleys to suit the machine.

Countershafts, hangers, and pulleys will be provided for each of the above tools.

151. Distilling Apparatus and Evaporators—The distilling apparatus, placed where directed, will consist of two evaporators and two distillers, with their accessories, having a combined capacity of 7,500 gallons of potable water per 24 hours at a temperature of not more than 90° F.

The evaporators will be made with shells of plate steel. They will be either horizontal or vertical, and will be subject to the approval of the Bureau of Steam Engineering. The tubes will be of such design that they can be readily removed for scaling or repair, with adequate provision for expansion, and will be secured to the tube sheet in an approved manner. They will be either straight, bent, or coiled as the Bureau of Steam Engineering may approve. The tubes must be so arranged that after the

system is removed from the shell it will be accessible in all its parts for scaling. They will be felted and lagged, and will each be fitted with a safety valve, steam gauge, glass water gauge, gauge cocks, salinometer pot, and blow valve. They will take steam from the auxiliary steam pipe, and will be fitted with automatic traps and with drainpipes leading to the feed-tank pumps. The shells of the evaporators will be tested to 50 pounds to the square inch, and the coils and all parts subject to boiler pressure to 230 pounds per square inch. Each evaporator will have at least 115 square feet of heating surface.

The distillers will be made with shells of sheet brass, flanges and heads of composition, and coils of copper or brass, thoroughly tinned on both sides. The coils of each distiller will be divided into at least three parts, each with a separate inlet and outlet valve.

The distillers will be so arranged that they can take steam from the auxiliary steam pipe in an emergency.

A filter, of approved design, will be fitted to each distiller.

There will be efficient means for aerating the steam used in making distilled water.

There will be five (5) steam pumps, of approved pattern, for the following purposes :

One pump of 2⅜ inches water cylinder x 5 inches stroke, for pumping distilled water from distiller to fresh-water tanks or to the main-feed tanks at will.

One pump of same capacity drawing brine from evaporator and discharging into the circulating-pump discharge beyond the feed suction.

The fresh-water and brine pumps can be consolidated into one double pump, with the steam cylinder between the two water cylinders, 4 inches in diameter.

The fresh-water cylinder will have no copper or lead, and will have a pipe leading from its suction pipe to above the awnings with a regulating valve so that air can be forced into the tanks with the water. In the water suction of this pump will be fitted an approved water meter, made without copper or lead. The discharge pipes of this pump will lead to the bottom of the fresh-water tank, so that the air forced in will rise through the water.

One pump with a capacity of 20 gallons per minute at ordinary speed, for feeding the evaporators, drawing its water from the overflow of the circulating water through the condenser.

One pump with a capacity of 250 gallons per minute, for circulating the water for condensation around the distiller coils, and to have a steam cylinder large enough to drive the pump as a fire pump. This pump will have a special sea valve, and its discharge will be so arranged that it can throw through either or both distillers or into the fire main through a by-pass valve.

One duplex pump, 2 x 1⅛ x 2¾ inches stroke, equal to Worthington standard, fitted with metal valves for pumping condensed water from traps to the main feed suction. This pump to be placed below the level of the evaporators.

The condensing water after leaving the distillers will be led forward by a pipe of approved size, with connections for flushing the crew's water closets, with branches to the officers' water closets. This pipe must be placed so that water will flow to all the closets at the same time. A by-pass pipe will be provided so that water may pass to the closets when the distillers may be shut off.

The evaporators and distillers will be so fitted that their coils can be easily removed for repairs. There must be no internal detachable joints in the coils of either evaporators or distillers.

152. Refrigerating Plant.—There will be an ice machine of the "dense air" variety capable of making one ton of ice per day. It will have cooling pipes as directed, to the ice tank, to the cold storage or refrigerating room, and to the scuttle butt.

153. Wash-water Tanks, Etc.—There will be one or more wrought-iron tanks, of a combined capacity of 400 gallons, to hold fresh water for firemen's use. They will be fitted in such places as may be designated. Each tank will have an overflow pipe, without valve or cock, leading to the bilge, with the end in plain view from the fire room; also a drainpipe with its valve easily reached from the

fire room. A pipe will be led direct from the fresh-water outlet of the distiller for filling these tanks without passing the water through the filter; this pipe to have a locked cock.

There will be an approved hand pump connected as follows: To have suction pipes from the feed-tank suction pipe and from the tanks above mentioned, and to discharge into these tanks and into the tank in the firemen's washroom; all pipes fitted with stop valves close to the pump. The pump will have a dead-weight relief valve set at just sufficient pressure to allow the washroom tank to be filled.

A cylindrical copper tank of about 50 gallons capacity will be fitted in the firemen's washroom, and connected with the pump above specified. The tank will be supplied with a vent pipe with a float valve, which will close the vent when the tank is full. There will be a service pipe from the tank, with a branch to each wash basin, and one for filling buckets. Each of these branches will have a self-closing lever faucet. In the service pipe, close to the tank, will be a locked cock.

154. Main Steam Pipes.—The main steam pipes will be of copper, the thickness in accordance with the formula hereinafter furnished.

The pipes will run from the forward boiler aft to the engines. On the port side from the forward boiler the pipe will be 10½ inches inside diameter, till it is met by a 10½-inch pipe from the after boiler, where it will be enlarged to 14½ inches inside diameter, and carry that size to the engine

On the starboard side the pipe will leave the forward boiler with a diameter of 7½ inches inside diameter, carrying that diameter till it is met by a 7½-inch pipe from the next boiler aft, when it will be enlarged to 10½ inches, which will be the diameter until it is entered by a 10½-inch pipe from the after starboard boiler, when it will be enlarged to 14½ inches, and keep that size to the engine.

From a connection in the after fire rooms and passing through the bunkers and engine rooms as shown there

will be a 10½-inch inside diameter pipe connecting the two main pipes, having a straightway valve on each end. There will be a straightway valve on each main steam pipe forward of where the branch crosses the after fire room, and also in each engine room just abaft the bulkhead. Each of these straightway valves to be provided with by-pass valves.

The copper main steam pipe will be banded at intervals along its whole length when it is of and above 10 inches internal diameter, with ⅛-inch steel bands 2 inches wide, spaced 6 inches between centers.

The bands will be of approved design, and will be provided with tension screws or keys. Suitable and approved means must be provided for taking up expansion in the steam pipes, and all T's and short bends must be made of composition of approved thickness.

155. Auxiliary Steam Pipes.—There will be an auxiliary steam pipe, extending through engine and boiler compartments and to the windlass, steering, dynamo, and ventilating-fan engines, and to the engineer's workshop. It will connect with the auxiliary stop valves on each boiler and with the main steam pipe in each engine room abaft the separator. There will be a stop valve in the after part of each boiler compartment, close to the bulkhead, one in each engine room close to the bulkhead, and one in each connection with the main steam pipe. Branches will extend to all auxiliary machinery herein specified. The pipe will be of sufficient size to supply all auxiliary machinery, including dynamos and ventilating fans, when taking steam from abaft the separators. The auxiliary steam pipe will be arranged, where possible, so that steam condensing in it may drain back to the separator. Where it is not possible to so arrange it, or wherever pockets necessarily occur, the pipe will be drained and trapped. All branches from the pipe to pumps or engines on a lower level will have the stop valve for such machinery close to the main pipe, with a spindle for working it from below, so that when the pump or engine is standing idle there will be no opportunity for water to collect in the vertical pipe leading to it.

A separate auxiliary steam pipe will be fitted connecting the dynamo engines with the boilers; there will be a stop valve on each boiler, and the pipes will lead as direct as possible to a separator placed near the dynamo engines; all dips and pockets to be carefully avoided. Valves will be fitted so that the branch leading to any boiler may be shut off when the boiler is not connected with the dynamo-engine pipes, and valves will be fitted in the pipes leading from the separator to each engine, so that the steam may be shut off from the pipes when the engine is not in use. The traps for the separators must be of the proper size, and will be fitted with by-pass pipes and valves, so that they may be cleaned without shutting steam off from the engines. There will be an approved reducing valve in the dynamo-engine steam pipe, placed as near the boilers as possible.

The drain pipes must be so fitted that it will be impossible for one dynamo engine to blow into another, or for one end of one cylinder to blow into the other end of the same cylinder.

Swing checks will be fitted in all drainpipes close to the cylinder or chest from which they lead, and the drain pipes will be joined by an approved **Y** or **T**. The drain pipes from the cylinders must not lead to a trap.

A plan of the piping and drains will be submitted to the Bureau of Steam Engineering for approval before any of the work is done upon it.

156. Auxiliary Exhaust Pipes.—An auxiliary exhaust pipe, of sufficient size for all auxiliary machinery herein specified, and for such other steam machinery as may be fitted in the vessel, will be fitted and connected to all auxiliary machinery herein specified. It will have nozzles for all other auxiliary machinery. It will have valves to direct the exhaust steam into either main condenser, into either auxiliary condenser, into either low-pressure receiver, or into the atmosphere through the escape pipe at will. At each connection with condensers and escape pipe the auxiliary exhaust pipe will be fitted with two stop valves so as to minimize the chance of an air leak.

The connection with the escape pipe will be made below the armored deck.

All exhaust pipes from engines above the armored deck leading to the condenser will be fitted with valves below the armored deck.

The dynamo-engine exhaust pipes must be so led and joined by an approved Y or T that one engine can not exhaust against another, or the unused engine be flooded, and swing check valves will be fitted in all exhaust pipes close to the valve chests.

157. Bleeder Pipes.—A 6-inch branch from the main steam pipe in each engine room will lead to each main condenser, with a stop valve operated from the working platform.

158. Intermediate and Low Pressure Steam Pipes.—A 4½-inch branch from the main steam pipe will lead to each intermediate, and a similar pipe to each low pressure valve chest, each with a stop valve.

159. Separators.—There will be in each 14½-inch main steam pipe in each forward engine room a centrifugal or other approved separator. They will be made entirely of cast steel and plate steel, each fitted with a well protected glass gauge of the automatic closing pattern, and an approved automatic steam trap, with drain delivering into feed tank. There will also be a drain connected directly to the separator, discharging overboard or into the main feed-pump suction at will.

160. Main Feed-pump Exhaust.—The exhaust pipes from the main feed pumps, in addition to the connection with the exhaust main, will be so arranged that the exhaust steam can be turned into the feed-pump suction instead of into the auxiliary exhaust pipe, chambers with suitable nozzles for this purpose being fitted in the suction pipes.

161. Escape Pipes.—There will be a 12-inch copper escape pipe abaft each smokepipe, extending to its top, finished and secured in an approved manner. This pipe will have branches leading to all the safety valves in its compartment and to the safety valves on the auxiliary boil-

ers. The auxiliary exhaust pipe will also lead into the escape pipes.

162. Feed Pipes and Suctions.—There will be two feed mains, one connected with the main feed pumps on the port side of the central bulkhead and the other connected with the auxiliary feed pumps on the starboard side of the central bulkhead.

The main feed main will run from the forward fireroom of the after boilers to the forward fire room of the forward boilers, where it will cross the bulkhead and connect with the main check valve of the forward single ended boiler. There will be branches from this main connecting it with the main check valves of all of the boilers. There will be valves so situated that either pump can be used on either or all of the boilers.

The auxiliary feed main will run from the engine room connecting with the auxiliary feed pump in the engine rooms to the fire room of the forward single-ended boiler. Connecting in the fire room with the 350-gallon, 260-gallon, and 90-gallon auxiliary feed pumps before specified.

Branches will lead from this main to the auxiliary check valves on each boiler and the valves will be so arranged that any one pump can be used on either or all boilers.

There will be two feed suction mains, one for each system of pumps. That connected with the main feed pumps will draw water from the feed tanks alone and will be equal in area to the combined area of the main feed-pump suctions; it will be of seamless brass or copper.

The suction main for the auxiliary pumps will be the same as that of the main pumps, but in addition there will be a branch connecting with the bilge in each boiler compartment and with a sea valve. This suction pipe will equal in area the combined area of the suction nozzles of the pumps drawing from it.

The main and auxiliary suctions will be connected across the engine rooms, having a valve in the auxiliary suction pipe forward of the cross connection, allowing the main feed pump to draw from both or either feed tank without connecting with the auxiliary suction.

All these pipes where possible will be placed above the floor plates. All valves, with the exception of boiler check valves, bilge and sea valves, will be straightway valves.

163. Feed-water Heater.—If directed, there will be for each fire room a feed-water heater of suitable size, placed where directed. Plans showing the type and arrangement of heater must be submitted to the Bureau of Steam Engineering for approval before work is commenced on them.

164. By-Pass Valves on Straightway Valves.—All straightway valves above 5 inches in diameter, subjected to pressure above 15 pounds per square inch, will have by-pass valves to relieve the valve when jammed on the seat.

They will be for straightway valves above 5 and to 8 inches, 1 inch in diameter; 8 to 12 inches, 1½ inches; above this, 2 inches.

165. Fire Main.—There will be a fire main of copper, 5½ inches inside diameter, extending through the engine and fire rooms, from the after end of the engine hatch to the forward fire-room hatch, located above the floor plates and below the protective deck.

From this main at the engine and forward fire-room hatches there will be two vertical branches extending to the upper deck (four in all), each branch 3 inches in diameter. From each of these vertical branches on each deck above the protective deck there will be branches passing through the bulkheads surrounding the hatches with straightway valves and hose connections on each branch outside the hatch.

Leading forward from one of the vertical branches in the forward hatch there will be a branch connecting to a hose nozzle in the magazine passing room and in the sick bay.

There will also be a branch leading aft from one of the vertical pipes in the engine hatch to the after magazine passing room. Each of these branches forward and aft

will have a straightway valve outside the hatch and also one immediately back of the hose nozzles.

These two latter branches will be led in such a manner as to avoid any interference with bulkheads or head room, or as may be decided upon by the Inspecting Constructor and Engineer.

Each pump mentioned in these specifications to be used as a fire pump will be connected with this main under the protective deck.

There will be a hose nozzle in each engine room and in each fire room, each connected to the fire main by a branch with a straightway valve between the main and the hose couplings.

All couplings will be for 2½-inch hose fitted with standard Navy thread.

There will be a reverse hose coupling on the auxiliary feed pipe for filling the boilers from a hose.

There will be a 1½-inch steam pipe leading from the auxiliary steam pipe to each bunker and hold for extinguishing fire. This pipe will have a valve in it next the auxiliary steam pipe and another at each coal bunker and hold bulkhead. The part inside of the bunker may be made of galvanized iron, all other pipe of copper.

All valves in the fire main and steam extinguishing pipes with the pipes from the pumps will be straightway composition valves. Drainpipes will be fitted to drain all parts of fire main and branches.

166. Pipes through Water-tight Bulkheads and Decks.—They will be made water-tight by stuffing boxes, flanges, or other approved means.

Pipes must not be led in such a manner that the angles or T's of bulkheads have to be cut. Holes through wooden decks, where pipes pass through, will have brass or copper thimbles, made water-tight, extending at least 3 inches above decks.

167. Pipes through Coal Bunkers.—They will be protected by iron casings, made in sections, easily removable for repairs. Pipes must not be led under openings of coal chutes.

168. Drain pipes and Traps.—All places where condensed steam can accumulate will be provided with drainpipes and cocks or valves of ample size, and with approved automatic traps, which will discharge into feed tanks or condensers, or as directed. All traps will have by-pass pipes and valves for convenience of overhauling. The lowest parts of all water pipes and all pump cylinders and channel ways will have drain cocks with pipes, where required. The handles of all drain cocks will point downward when closed. All glass water gauges under pressure will be fitted with valves of approved automatic closing pattern.

169. Thickness of Pipes.—The thickness of copper straight steam piping fire service and blow-off pipes will be found by the following formula:

$$\frac{P \times D}{8000} + \frac{1}{16} = T.$$

Where P = boiler pressure above atmosphere.
D = inside diameter of pipe.
T = thickness in inches.

The thickness of feed pipe will be found by the same formula with the exception that P = 1.5 boiler pressure above atmosphere.

The thickness for feed-suction piping will be as follows:

Of 1 and less than 3 inches internal diameter, $\frac{1}{8}$ inch;
Of 3 and less than 5 inches internal diameter, $\frac{5}{32}$ inch;
Of 5 and less than 8 inches internal diameter, $\frac{3}{16}$ inch.

Water pipes without pressure will be—

Of 2 and less than 5 inches, $\frac{3}{32}$ inch;
Of 5 and less than 11 inches, $\frac{1}{8}$ inch;
Of 11 and less than 15 inches, $\frac{5}{32}$ inch;
Of 15 and less than 20 inches, $\frac{3}{16}$ inch.

All copper piping will be No. 1, B. W. G., thicker in the bends than in straight parts.

All exhaust and other pipes not in the above list will be made of approved thickness.

170. Material and Fitting of Pipes.—All pipes, except the lower end of bilge-suction pipes, will be of copper, unless otherwise specified.

The lower parts of bilge-suction pipes will be of galvanized iron. All copper and brass piping of and less than 6 inches diameter will be seamless drawn. All copper pipes not seamless drawn will be brazed. All copper pipes over 5½ inches in diameter will have composition flanges riveted on and brazed, and will have the end of the pipe expanded into a recess in the face of the flange, and all under 5½ inches will have flanges or approved composition couplings brazed on, and the end of the pipe will be expanded into a recess in the face of the flange. All feed and blow pipes will have composition flanges. All flanges of high-pressure pipes will be in accordance with the Bureau of Steam Engineering table of thickness of pipes and flanges, and will be faced and grooved, and joints between flanges in steam pipes will be made with asbestos board soaked in boiled linseed oil, "Usudurian" with wire gauze, "Vulcabeston," or other material, samples of which must be submitted to the Bureau of Steam Engineering for approval before using.

No material will be used that will not withstand the heat of the steam and keep tight an indefinite length of time, and any material used must be the best that can be procured. All composition flanges below the floor plates will be connected by bolts and nuts of rolled naval brass or Tobin bronze. All copper pipe, T pieces, and fittings will be of composition, except where otherwise directed. Expansion joints of approved pattern will be fitted where required. Slip joints, if fitted, will have stop bolts and flanges. All copper pipes in bilges will be well painted and covered with water-proof canvas, and must not rest in contact with any of the iron or steel work of the vessel.

All steam, air, and water pipes of refrigerating machines will be of copper, with flange joints; all other pipes will be fitted with flange joints, to be approved by the Bureau of Steam Engineering.

All slip joints will consist of a composition stuffing box, follower, and entering pipe, the stuffing box and entering pipe to be connected by flanges with the copper pipe.

All slip joints to be packed with metallic packing to be approved by the Bureau of Steam Engineering.

171. Auxiliary-engine Stop Valves.—Each auxiliary engine will have stop valves in exhaust pipes as close to cylinder as possible. Exhaust stop valves will be straightway where practicable. All pumps, except circulating pumps, will have screw check valves in both suction and delivery pipes close to pump cylinders, so arranged that they may be kept off their seats when desired.

172. Pump Cylinders.—All pump cylinders, together with their valve boxes and fittings, will be made of composition, and the cylinders over 6 inches diameter will be fitted with working linings for convenience in reboring, unless otherwise specified. Air chambers will be fitted on the delivery sides of pumps or in the pipes, as may be directed.

The water cylinders of all vertical pumps will be so arranged that the pistons are easily accessible and fitted for overhauling without disturbing the framing or piping. All pumps will have either packed pistons or packed plungers, excepting air pumps, which will be made as shown.

173. Pump Relief Valves.—All feed and fire pumps will have adjustable spring relief valves of approved design, connecting the delivery and suction passages.

174. Sea Valves.—There will be in the various compartments sea valves as follows:

In each engine compartment a screw-stop valve, having independent connection to the side of the vessel, of sufficient size to supply water to the fire, bilge, and the auxiliary pumps in that compartment, also with a 4½-inch nozzle for connection of the water-service pipes. Also in each engine compartment a double valve box with a screw non-return valve for the discharge from the fire and bilge and auxiliary pumps, and a non-return valve for trap discharge. This valve box may, if desired, be connected to the outboard nozzle of the main outboard-delivery valve. The main injection and outboard-delivery valves will be as elsewhere specified.

In each main boiler compartment there will be a screw-stop valve for a bottom blow and pump discharge, and a sea valve for each auxiliary pump sea suction.

There will also be a sea-suction valve for the distiller circulating pump, placed where directed.

All these valves will be of composition, with the screws on the stems outside the chamber, the screws passing through a crosshead supported by iron or steel stanchions.

175. Bilge Strainers.—Each pipe leading from the bilges or from the drainage system of the vessel to the pumps will be fitted with a Macomb (or approved equivalent) strainer, above the floors.

The baskets of Macomb strainers will have a diameter equal to one and one-half times the diameter of the pipe, and a length equal to twice the diameter of the pipe, except in the case of the bilge injections, which strainer will be the same diameter as the pipe.

176. Attachment of Valves to Hull.—Steel strengthening rings will be riveted to plating of hull around the openings for all sea valves. The valve flanges will be bolted to these rings by rolled manganese or Tobin bronze studs, care being taken not to drill the holes entirely through the rings. A zinc protecting ring will be fitted in each opening in outer skin in such a manner as to be easily renewed.

All suction valves will have strainers over their openings on the outside of the vessel. These strainers will have $\frac{5}{8}$-inch holes with a collective area equal to twice the area of the valve openings. Strainers must be fastened to valve pipes or casings, and not to the plates of the hull.

All sea valves over the double bottom will be inside the inner skin and connected to the outer skin by a cast or plate steel pipe, secured by riveted flanges to both inner and outer skins. There will be a steel stiffening ring on the inner bottom to which the valve chamber will be bolted. A zinc protecting ring will be secured to the lower flange of the valve chamber.

177. Cocks and Valves.—All cocks and valves and their fittings, except as otherwise specified, will be of composition. All hand wheels will be of finished brass, except

as otherwise specified, and will be at least one and one-half times as great in diameter as their valves. All cocks communicating with vacuum spaces will have bottoms of shell cast in and have packed plugs. All cocks over 1 inch in diameter will have packed plugs. Reducing valves will be put in where directed or required.

Valves of approved pattern will be supplied wherever necessary to complete the various pipe systems, whether herein specified or not. All valves will be so fitted as to be easily ground in, and be fitted where required with grinding-in guides and handles. No conical-faced valve will have a bearing on its seat of more than $\frac{3}{16}$ inch in width. All valve spindles must turn right-handed to close, and have outside threads where practicable. Cocks and valves may have, where approved, in lieu of wheels or permanent handles, removable box or socket wrenches, marked and stowed in convenient racks; these handles to be so fitted that they can only be removed when the valves are closed. All cocks and valves underneath the floor plates will have their wheels or handles above the floor plates, in easily accessible positions, unless otherwise directed. The sizes of valves as given in these specifications refer to the diameter of the equivalent clear openings.

178. Labels on Gear and Instruments.—All cocks will have engraved brass plates to show their uses and to indicate whether open or shut. All valves, except such as may be otherwise directed, will have similarly engraved plates to show their uses, or have the same plainly engraved on hand wheels.

All hand levers or their quadrants will be similarly marked. Gear for working valves from deck will be marked as elsewhere specified.

All main steam stop valves will have indices to show to what extent they are opened.

All gauges, thermometers, counters, telegraph dials, speaking-tube annunciators, and revolution indicators will be suitably engraved to show to what they are connected.

All engraving will be deep and be filled in with black cement.

179. Clothing and Lagging. — The main cylinders and valve chests, excepting upper cylinder heads, after being finally secured in place in the vessel and tested, will be covered with approved incombustible non-conducting material and neatly lagged with black walnut all over, secured with polished brass bands and round-headed brass screws. The upper cylinder heads will be covered with a neatly fitting iron floor plate with flat-topped corrugations.

The lagging will be made in removable sections over each valve chest and manhole cover, parts plainly marked. The lagging elsewhere will be so secured as to be easily removed, replaced, and repaired.

All parts of the condensers except the water chests at ends will be clothed with approved material put on in sections so as to be easily removed and replaced, and neatly lagged with black-walnut lagging secured by brass bands and round-headed screws.

All steam and exhaust pipes, the separators, the feed-water heaters, and all steam valves will be clothed in an approved manner with a satisfactory non-conducting material, covered with canvas, well painted. The main steam and exhaust pipes in engine room and the main separators will be also covered with black-walnut lagging with brass bands. The canvas covering of steam pipes will be secured to bulkheads where the pipes pass through them.

The main steam pipes, where they pass through bunkers, will in addition be inclosed in a water-tight covering of galvanized iron.

The steam cylinders of all auxiliary engines will be clothed and lagged the same as main cylinders.

The feed tanks will be covered with ¾-inch cow hair felt with canvass back and lagged with black walnut lagging with brass bands.

After the boilers are in place and have been tested and painted, they will be covered all over, except where

directed, as low as the saddles, with approved incombustible non-conducting material at least 1½ inches thick. This clothing will be covered on tops, sides, and back heads and on fronts, where required, by galvanized wrought-iron plates, about No. 18, B. W. G., flanged not less than 1 inch and bolted together; also secured to boiler plates at bottom by angle iron, which will be held in place by ½-inch bolts tapped part way into the boiler plates and held off from the boiler plates elsewhere by suitable distance pieces.

180. Radiators.—Radiators of approved patterns, with such areas as may be called for in the specifications for radiators to be furnished by the Bureau of Steam Engineering, will be furnished and fitted and connected.

Each radiator or coil of more than 10 square feet will be divided into two parts. All radiators will be fitted with approved valves, with valve-stem guards, and removable keys for valve stems. The ends of the stems will be triangular in cross section.

The radiators in the wardroom, cabin, and steerage will consist of pipes led along the deck at the bottom of the bulkheads, and will be covered with an approved metallic casing easily removable.

The steam and drain pipes will be of seamless drawn brass, of iron pipe size, suitably connected by composition fittings in a manner that will permit them to be easily taken down for repairs.

All union joints will be coned or have corrugated copper washers.

All holes through decks and bulkheads will be thimbled with brass.

Steam and drain pipes will be clothed where near woodwork, and elsewhere as required.

The steam pipes will connect with the auxiliary steam pipes where directed, and be fitted with adjustable reducing valves.

The drainpipe of each circuit will have an approved automatic steam trap discharging into feed tank, and elsewhere as directed.

Independent steam pipes will lead from engine and fire rooms to the principal divisions of the officers' quarters and forward parts of the ship.

181. Whistles.—An approved polished brass chime steam whistle, with a bell of about 8 inches diameter, will be placed forward of the forward smokepipe, well above the level of the awnings, and connected to the auxiliary steam pipe by a pipe having a stop valve at its lower end and a working valve at the upper end. The pipe will have an expansion joint at lower end. There will be a shrieking whistle of approved pattern and size placed where directed, and connected similarly to the whistle. Both whistle connections will have drainpipes fitted at the lowest points.

182. Hose and Hose Reels.—A sufficient length of hose will be supplied for each engine room and each fire room, to lead to the farthest part of the adjoining coal bunkers below the armored deck. The hose for engine rooms will be of the best quality rubber-lined linen, and that for fire rooms will be the best quality four-ply rubber engine hose; all 2½ inches diameter, with standard couplings. Each hose will be supplied with a rubber hose pipe with handles. A pair of spanners will be supplied for each hose nozzle.

A hose reel of approved pattern will be fitted in each fire room, and a swinging bracket or similar hose receptacle in each engine room. Hose pipes and spanners will be fitted in beckets.

183. Shafts through Bulkheads.—All shafts passing through water-tight bulkheads will be fitted with stuffing boxes, each in two parts.

184. Floors and Platforms.—The engine rooms and fire rooms will be floored with wrought-iron plates ¼ inch thick, with neatly matched flat-top corrugations. The plates will be of convenient size and easily removable. They will rest on proper ledges of angle or T iron, and will have drain holes where necessary. Platforms will be provided for getting at all parts of the main and aux-

iliary engines and boilers. These platforms, where placed over moving machinery, will be fitted the same as the lower floors. In other places they will be made of iron rods ⅝ inch square, placed 1¼ inches apart.

185. Ladders.—Ladders will be fitted wherever necessary for reaching the engine rooms and fire rooms from deck, and for reaching the various platforms, passages, and parts of machinery. The engine-room ladders will be made with plate-iron sides and light cast-iron treads with corrugated tops, and the main ladders from deck to engine rooms will be 2 feet wide in the clear. The fire-room ladders will be made with plate sides and double square-bar treads.

All ladders will be so fitted as to be easily removable where required, and will be joined and hinged, with necessary fastenings and gear, where they have to be moved when closing hatches. Light iron ladders will be fitted to and through one ventilator in each engine room as means of egress when the battle hatches are closed.

Gear will be provided for quickly opening the battle hatches over the fire-room ladders, this gear to be worked from fire rooms.

186. Hand Rails.—Hand rails, easily removable where required, will be fitted to all ladders and platforms around moving parts of machinery, and along bulkheads and passage ways. The hand rails and stanchions will be made of approved metal which will not easily tarnish, and will be polished all over. The lower ends of stanchions will pass through floor plates with nuts underneath. Stanchions supporting hand rails will be perpendicular to floor plates or treads of ladders.

187. Gear for Working Valves from Deck.—The safety valves, boiler stop valves, and engine-room stop valves, as elsewhere specified, will have suitable gear for working them from the main deck.

The rods of the gear will be guided and supported on deck by cast-iron composition standards, left rough and painted. Each rod will have polished brass bar handles fitted to squares on the turning rods, and will be stowed

in beckets on bulkheads. The tops of rods will be protected by brass caps. Each to be fitted with a lock and key, all keys to be alike. All hand wheels will be engraved with name, or cast-brass label plates with polished raised letters will be fixed to adjoining bulkheads.

188. Lifting Gear.—Efficient lifting gear, consisting of traveler bars and pulleys, deck-beam clamps, turnbuckles, shackles, hooks, eyebolts, as may be directed, will be fitted wherever required for lifting parts of the machinery for overhauling and repairing.

Holes will be tapped in all the principal movable parts of machinery for this purpose.

189. Oil Tanks.—Oil tanks of 2,200 gallons total capacity, divided as directed, will be fitted where directed, with facilities for filling from deck. They will be made of galvanized wrought iron not less than ⅛ inch thick, and will each have a glass gauge, a manhole and cover near the top, and a locked cock for drawing oil. In each engine room there will be fitted two copper oil tanks of 20 gallons each and two of 8 gallons each, and in each boiler compartment one of 5 gallons, all with lock cocks. All oil tanks will be fitted with drip pans.

Each of the larger oil tanks will have a hand pump and pipes for filling the smaller tanks.

Two galvanized-iron tallow tanks, with hinged covers, will be fitted where directed.

190. Ventilators.—Ventilators, with cowls well above the awnings, will be fitted as may be required.

The ventilators will be of wrought iron, No. 11, B. W. G., butted and single-strapped and flush-riveted. Where cowls are fitted they will be movable, of No. 12, B. W. G., copper, not planished. The base rings of cowls will be of composition, finished on working parts, but left unfinished on the outside. All cowls will be fitted with gear for turning them from the engine and fire rooms, the gear to be of composition except the spindles, which will be of wrought iron. Brass hand wheels or T handles will be fitted to spindles in engine and fire rooms.

There will be at least one ventilator in each fire room, fitted with all appliances for hoisting ashes. Fire-room ventilators will be provided with air-tight doors to prevent escape of air when the fire rooms are under pressure.

Fire-room ventilators coming near compasses will be made of copper above protective deck.

191. Steam-launch Machinery.—The machinery of steam cutters will be fitted with boilers and engines which will meet the approval of the Bureau of Steam Engineering, and drawings must be submitted before work is commenced on them.

192. Tools.—The following tools will be furnished in addition to those elsewhere specified:

One set of wrenches complete for each engine and each fire room, to be fitted for all nuts in their respective compartments, plainly marked with sizes, and fitted in iron racks of approved pattern. The wrenches for nuts of bolts less than one inch in diameter will be finished, and for all over two inches in diameter will be box wrenches, where such can be used. Socket wrenches will be furnished where required. Open-end wrenches will be of steel or wrought iron with case-hardened jaws, all others of wrought iron or cast steel;

One pair of taps, on rods, for tapping front and back tube sheets of main boilers at one operation. This will be a duplicate of that used in originally tapping the sheets, and be so packed as to be perfectly protected from injury;

A fixed trammel for setting the main valves without removing the covers; the valve stems to be properly marked for this purpose;

Fixed trammels or gauges for aligning crank shafts, brass pins being let into pillow blocks and center marked for this purpose;

Two complete sets of fire tools for each fire room;

Six coal and six ash buckets for each fire room.

All trammels and gauges will have protecting cases. All tools will be conveniently stowed.

193. Duplicate Pieces.—The following duplicate pieces, in addition to others specified, will be furnished, fitted, and ready for use, viz:

One set of valves for each pump;

One-half set of follower bolts and nuts for each steam piston;

One-half set of springs for each steam piston;

Two bottom brasses and two caps for crankshaft bearings;

One-half set valve guards and bolts for one air pump;

If horseshoe thrust bearing is used, one set horseshoes for one bearing;

Two crown brasses and two butt brasses for crank pins;

Two caps and two butt-brasses for crosshead journals;

Two cast-steel slippers complete for crossheads;

A full set of blades for each propeller, fitted to propeller bosses—these blades will be of such pattern as may be directed after the trial of the vessel;

One complete set of brasses for each main engine valve gear;

One complete set of brasses for each circulating-pump engine, each air-pump engine, each main feed pump, each fire pump, and each blowing engine;

One piston rod for each piston of each pump;

One feed check valve, complete;

One bottom blow valve, complete;

One surface blow valve, complete;

One complete set of metallic packing for each size stuffing box in addition to four sets for piston rods;

A spare hose and nozzle for each steam tube cleaner;

One-eighth of a complete set of grate bars and bearers for all furnaces, and one pattern for each casting;

Four dead plates for furnaces and one pattern for same;

Two ash-pit doors;

Twenty stay tubes for each double-ended and 10 for each single-ended boilers, threaded to fit threads in tube sheets, with ends wrapped in canvas;

Fifty ordinary boiler tubes for each double-ended and 25 for each single-ended boiler, swelled at one end and annealed, ready for use;

Two spare boiler manhole plates of each size, complete with bolts, nuts, and yokes.

One hundred and fifty main condenser tubes, packed in boxes;

Twenty-five auxiliary condenser tubes, packed in boxes;

Two hundred condenser-tube glands;

One spare spring for each safety valve and relief valve;

One spare basket for each Macomb bilge strainer;

One set of coils for each evaporator, or one set of tubes if straight tubes are used.

Wherever duplicate pieces are furnished for one of two or more pieces of machinery of the same size, they will be made strictly interchangeable.

All finished duplicate pieces not of brass, except as otherwise specified, will be painted with three coats of white lead and oil and well lashed in tarred canvas, with the name painted on outside. Brass pieces will be marked or stamped. All pieces will be stowed in an approved manner.

All boiler tubes will be securely stowed in racks, or as directed.

194. Materials and Workmanship.—All castings must be sound and true to form, and before being painted must be well cleaned of sand and scale, and all fins and roughness removed.

No imperfect casting or unsound forging will be used if the defect affects the strength or to a marked degree its sightliness.

All nuts on rough castings will fit facings raised above the surface, except where otherwise directed. All flanges of castings will be faced, and those coupled together will have their edges made fair with each other. The faces of all circular flanges will be grooved.

All bolt holes in permanently fixed parts will be reamed or drilled fair and true in place, and the bodies of bolts finished to fit them snugly.

All pipes beneath floor plates will be connected by forged bolts and nuts of rolled manganese or Tobin bronze.

All brasses will fit loosely between collars of shafting.

All brasses or journals will be properly channeled for the distribution of oil.

Packing for stuffing boxes will be such as may be approved.

All small pins of working parts will be well case-hardened.

All steel joint pins or valve gear will be hardened and ground to true cylindrical surfaces.

All material used in the construction of the machinery will be of the best quality. The iron castings will be made of the best pig iron, not scrap, except in cylinder liners and where otherwise directed.

Composition castings will be made of new materials.

The various compositions will be by weight, as follows:

For all journal boxes and guide gibs where not otherwise specified: Copper 6, tin 1, and zinc ¼ parts.

Naval brass: Copper 62, tin 1, and zinc 37 per cent.

For composition not otherwise specified: Copper 88, tin 10, and zinc 2 per cent.

Muntz metal will be of the best commercial quality.

Anti-friction metal will be of approved kind.

Ornamental brass fittings will be of good uniform color.

All castings will be increased in thickness around core holes. Core holes will be tapped and core plugs screwed in and locked, except where bolted covers are used, or where it may be directed that the holes be left open.

All steel forgings will be without welds and free from laminations.

All flanges, collars, and offsets will have well rounded fillets.

All boiler plates, stays, and tubes will be well cleaned of mill scale by pickling or other approved means.

All flanged parts of boilers will be annealed, after flanging, in an approved manner.

India-rubber valves will be of approved kind, of best commercial quality.

All bolts for securing the boiler attachments will, where practicable, be screwed through the boiler plates, with heads inside.

All work will be in every respect of the first quality and executed in a workmanlike and substantial manner.

Any portion of the work, whether partially or entirely completed, found defective, must be removed and satisfactorily replaced without extra charge.

195. Tests of Material.—All steel used in the construction of the boilers, and all steel forgings and castings, will be tested in accordance with rules prescribed by the Navy Department.

All boiler and condenser tubes will be tested to 300 pounds pressure per square inch, applied internally before being put in place.

India-rubber valves, taken at random, must stand a dry-heat test of 270° Fahr. for one hour, and a moist-heat test of 320° Fahr. for three hours, without injury.

196. Tests of Boilers and Machinery.—Before the boilers are painted or placed in the vessel they will be tested under a pressure of 250 pounds to the square inch above atmospheric pressure. This pressure will be obtained by the application of heat to water within the boilers, the water filling the boilers quite full.

The steam pipes and valves, the auxiliary engines, and all fittings and connections subjected to the boiler pressure will be tested by water pressure to 250 pounds to the square inch. After the boilers are placed in the vessel and connections are made the boilers and pipe connections will be tested by steam to 200 pounds per square inch, and all leaks to be made tight before they are clothed.

The high-pressure cylinders, jackets, and valve chests will be tested by water pressure to 240 pounds to the square inch, the intermediate-pressure cylinders and connections to 150 pounds, and the low pressure to 100 pounds. The exhaust side of the low-pressure valve chests will be tested to 30 pounds. The condensers will be tested to 30 pounds.

The pumps, valve boxes, and air vessels of the feed, fire, and bilge pumps will be tested to 300 pounds per square inch. The cylinders and condensers will be

tested before being placed on board, and must be so placed that all parts may be accessible for examination by the Inspector during the tests. All parts will also be tested after being secured on board. No lagging or covering is to be on the cylinders or condensers during the tests. All pressures to be above atmospheric pressure.

The circulating pumps will be tested by discharging water under conditions as nearly as possible like those they will be working under when throwing water from the bilges. They must discharge the water at the same height as the water line is above the pumps and through the same length and size of pipe, drawing water from the same depth as the lowest part of the bilge suction pipe below the pump and through the same length and size of pipe.

197. Painting.—After a satisfactory test the boilers will be painted on the outside with two coats of brown zinc and oil, and when in place the fronts will be painted with one coat of black paint.

All engine work, not finished, will be primed with two coats of brown zinc and oil, and when placed in position on board the vessel will be painted with two coats of paint of approved color. The shafting, when in place, will be painted with two coats of red lead and oil and two coats of black paint.

The smokepipes will be thoroughly painted before and after erection on board. The ventilators and cowls will be painted similarly to the smokepipes, except the interiors of the cowls, which will be painted vermilion.

All pipes will be painted in accordance with a schedule to be hereafter furnished.

198. Preliminary Tests and Trials.—Steam will not be raised in the boilers until after the water test on board, unless desired for drying or testing joints, for which purpose the pressure must not exceed 10 pounds per square inch.

After testing, steam will be raised in the boilers whenever required to test the connections and the workings of all parts of main and auxiliary engines.

All expense of such preliminary tests will be borne by the contractor.

199. Superintending Engineer's Office.—A suitable office and a suitable drafting room, properly furnished and heated, will be furnished by the contractor for the use of the superintending naval engineer and his assistants.

200. Record of Weights.—All finished machinery, boilers, and appurtenances thereof, as fitted, and all spare machinery and tools herein specified, will be weighed by the contractor in the presence of the superintending naval engineer, or one of his assistants, before being placed on board; and no part of the material will be placed on board without being so weighed, to the satisfaction of the superintending naval engineer.

201. Working Drawings.—All drawings necessary for the prosecution of the work must be prepared by and at the expense of the contractor.

Those which are developments of the drawings furnished and of these specifications will be subject to the approval of the Bureau of Steam Engineering before the material is ordered or the work commenced.

In the drawings furnished, figured dimensions, where given, will be followed, and not scale dimensions, unless otherwise directed. All discrepancies discovered in drawings, or between drawings and specifications, will be referred to the Bureau of Steam Engineering.

A copy of each working drawing will be furnished to the superintending naval engineer before the work shown by the drawing is commenced. A copy of each drawing accompanying orders for steel castings or forgings will also be supplied when the work is ordered.

202. Drawings of Completed Machinery.—The contractor will make and furnish to the Bureau of Steam Engineering, through the superintending naval engineer, a complete set of drawings of the boilers, machinery, and appurtenances as actually completed, including plans of the same as fitted on board the vessel. These drawings will include every piece of machinery, both in whole and

in part, and will be in such detail as would enable the entire machinery to be duplicated without additional drawings. No sheet will contain drawings of more than one part of the machinery, except those intimately connected with each other. The detail drawing of each part of the machinery will be furnished within one month after the completion of the part, without waiting for its incorporation into the machine as a whole. Detail drawings will be made to a scale of not less than 1½ inches to the foot. General plans of the machinery in place in the vessel will be made to a scale of ¼ inch to the foot.

The pipe plans will be made to a scale of not less than ⅜ of an inch to the foot. The pipe plans will be divided into at least two parts—one showing steam and exhaust pipes, and the other showing all other pipes. The pipe plans will be colored in accordance with a schedule to be furnished, to indicate the purpose which the pipes are intended to serve, and accompanied by an explanatory index.

All drawings will be made on the best quality of tracing cloth; all sheets being, as far as possible, multiples or sub-multiples of double-elephant size.

Detail drawings will be hatched, where in sections, in accordance with a schedule to be furnished, to show the various metals employed.

203. Changes in Plans and Specifications.—The contractor will make no changes in the plans or specifications without the approval of the Navy Department. In case it is thought advisable to make changes, the contractor will make application by letter to the Bureau of Steam Engineering, through the superintending naval engineer, stating the nature of the change, accompanied by complete plans and specifications of the proposed change, together with a statement of his estimate of the amount of increase or decrease in cost.

204. Inspection.—The work of construction of the boilers, machinery, and appurtenances shall be at all times open to inspection by officers appointed for such purpose by the Navy Department. Every facility will be

afforded such inspectors for the prosecution of their work. All handling of material necessary for purposes of inspection will be done at the expense of the contractor. All test specimens necessary for the determination of the strength of material used will be prepared and tested at the expense of the contractor. The contractor will furnish the superintending naval engineer with a weekly list of the number of men of each class employed upon the work, together with a statement of the number of hours labor in each class.

205. Omissions.—Any part of the machinery or any article pertaining thereto which may have been inadvertently omitted from these specifications or from the official drawings, but which is necessary for the proper completion of the vessel, is to be supplied by the contractor without extra charge.

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